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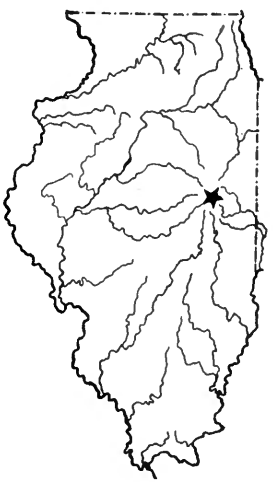
THE INSECT PESTS OF CLOVER AND ALFALFA

By J. W. FOLSOM



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THE INSECT PESTS OF CLOVER AND ALFALFA

By J. W. FOLSOM, Assistant Professor of Entomology, University of Illinois

Introduction

This account contains a large amount of new information on the most injurious of the clover insects, and on some of the less important species as well. Unless otherwise indicated, the observations were made by the writer during three summers in which he was employed by the State Entomologist, Dr. Stephen A. Forbes, for the special purpose of studying these important insects.

The volume of the results obtained—many of them as yet unpublished—is due in no small measure to the help of an assistant, especially in the routine work of the insectary; and in this capacity there have served at one time or another, Messrs. E. V. Bronson, E. O. G. Kelly, R. L. Webster, and J. J. Davis. Their names appear later wherever their personal observations have been used.

The present account contains not only new material, but also everything of importance that has previously appeared in our literature of the subject. The literature is large, but the greater part of it is a mass of more or less useful repetition, which traces back to a few sources. All the original articles are cited in the lists of references, as are also the more useful of the compiled articles. These references, tho not voluminous, are comprehensive, and sufficient to guide one directly to all the authentic sources of information on each subject treated.

Most of the illustrations were drawn for the State Entomologist by Miss Charlotte M. Pinkerton, Mr. F. Knab, and Mr. W. C. Matthews. Several electrotypes were obtained from the Bureau of Entomology thru the courtesy of the Chief, Dr. L. O. Howard.

In the account that follows, consideration is given primarily to the insect pests of red clover, and secondarily to those of mammoth clover, white clover, alsike, and alfalfa. The last-named plant, introduced into Illinois some ten years ago, is cultivated here and there in almost every county, and has been adopted as a food plant by a large number of the red-clover insects; but none of them have as yet injured it conspicuously, so far as the writer has been able to learn.

Injury to Clover by Insects

A field of red clover in full bloom is alive with insects. Such a profusion of insect visitants, both as regards number of individuals and number of species at one and the same time, is afforded by no other plant that we know of, with the possible exception of alfalfa. In the

clover fields of the university farm we have taken two hundred species of insects—not all of them injurious, tho more than half of them feed on the plant. Adding to these the other species that have been listed as feeding on clovers, vetches, and alfalfa, it is seen that these plants are food for more than two hundred different kinds of insects. A hundred more are predaceous or parasitic on these clover insects, or else feed on animal or vegetable matter in the soil of the clover field.

No part of the plant escapes attack. The roots are eaten by the larvæ and the beetles of the root-borer, as well as by those of half a dozen other species, and are drained of their sap by the mealy bug. The stem is hollowed out by the common stem-borer. Both the stems and the leaves are pierced by many hemipterous insects, especially aphids and jassids, and are eaten by a great variety of caterpillars, beetles, and grasshoppers, as are also the heads of the flowers. The ovule is destroyed by the maggot of the seed-midge, and the developing seed is eaten out by the seed-chalcid. Even clover hay is the special food of a certain caterpillar, hence called the clover hay-worm.

Some of the insects of the clover field are, of course, beneficial. Such are those that pollenize the flowers,—bumblebees and, to some extent, honey-bees,—as well as those that act as checks on the injurious insects.

Most of the clover insects are not limited to clover, but have other food plants as well. The seed-midge and the seed-caterpillar are, however, confined to the clovers, and the seed-chalcid to clovers and alfalfa, so far as known. The root-borer is said to eat peas as well as clover. The hay-worm has been found only on hay as yet, but the moth has been raised from masses of dead grape leaves taken in a vineyard. The leaf-weevil is reported from beans and timothy, as well as clover and alfalfa. The clover-louse has been a pest of the worst kind on peas and has a long list of food plants. Of the less important clover insects, a few have no other food plant; but the majority can easily maintain their existence when no clover is at hand.

In Illinois, where alfalfa is a recent introduction, its insects are essentially the same as those of red clover, and it has as yet no insects peculiar to itself. The leaf-weevil, seed-chalcid, and root-borer feed on alfalfa, but not enough to have done any damage up to the present time. Even the numerous caterpillars, beetles, and grasshoppers that eat the foliage have not yet injured this newly introduced plant to any great extent. An insect that eats a few alfalfa leaves is not necessarily inflicting permanent injury upon the plant; for, up to a certain point, the plant is injured by leaf-eating insects no more than a fruit tree is injured by pruning. Red clover, also, is such a vigorous plant that it easily withstands or repairs injuries of an ordinary kind. Thus in April, 1907, 25 to 50 percent of the new leaves of red clover were frozen and killed in this region, but the hay crop was as good as ever. The temporary damage was far greater than that ordinarily inflicted by the miscellaneous clover insects—leaving out of consideration the seven pests named in the previous paragraph.

The combined efforts of all the insects, however, are sufficient to reduce the hay crop materially every year. Aside from the occasional conspicuous injury, there is every year a steady drain on the plant thru the attacks of insects. This annual drain is not noticed for the very reason that it occurs every year. If we could keep all the insects out of the clover field, we should get more hay. If we could exclude all except the bumblebees and the honey-bees, we should undoubtedly get an immense increase in the yield of seed.

Those who raise clover seed on a commercial scale owe their success to methods which operate chiefly against the insect enemies of the seed—whether the growers are aware of it or not. Under the same conditions of soil and climate, one man is able to get a good crop of seed and his neighbor is not. The reasons for this are chiefly entomological, as appears in these pages.

THE FAILURE OF THE SEED CROP

Many farmers do not attempt to raise their own clover seed. Those who do, get more or less of a crop according to circumstances. Here in the black soil of the corn belt, 1½ bushels of seed per acre is about the average yield for red clover (*Trifolium pratense*); the soil is not the best possible for clover; frequently too little seed is sown; generally the oats and the wheat are regarded as of more importance than the clover; and always the seed insects ravage the crop unless certain precautions are taken. In DeKalb county the soil is better adapted to clover, and, tho the winter conditions are now and then a little severe for the plant, the farmer expects to get about five bushels of seed to the acre by cutting the hay crop early. Under the most favorable conditions, red clover has yielded eight bushels per acre; I have found records of nine, but the more authentic accounts name no more than eight.

Many influences, more or less important, combine to reduce the crop of seed. Adverse mechanical or chemical conditions of the soil, or unfavorable conditions of the weather, may prevent the plant from flowering properly. With good conditions of soil and weather, the general health of the plant may be impaired by fungous diseases of several kinds or by insects, particularly the root-borer, the leaf-weevil, and the clover-louse; their devastations cause the heads to flower unevenly and imperfectly, and prevent the formation of a large number of heads in the crop directly attacked by them.

These injuries, due to influences that affect primarily the general health of the plant and secondarily the seed, are easily referable to their respective causes. The worst injuries to the seed are more insidious in their nature, and are caused by insects. These injuries are of three classes: (1) those of a negative kind, due to lack of pollination; (2) the positive injuries due to miscellaneous insects that eat clover heads in an incidental way; (3) the positive injuries caused by insects that feed solely upon clover seeds or florets. The first two groups are relatively unimportant in comparison with the last.

1. We should have no red clover seed at all were it not for the operations of the bumblebees and, secondarily, of the longer-tongued honey-bees (those of Italian races), for red clover is incapable of self-pollination. The importance of the bumblebee in the pollination of red clover is so well established as to need no discussion. That of the honey-bee, however, is not sufficiently recognized. The honey-bee pollenizes red clover to some extent, even tho its tongue is two millimeters shorter than the average corolla tube. A field of red clover is always thronged with honey-bees if any of them are being kept within a mile or two of the place; and these bees secure nectar from flowers that are undersized, especially in times of drought, when most of the flowers are smaller than usual; also from flowers that secrete a copious amount of nectar. Furthermore, the honey-bees, in their attempts to get the nectar, go thru the motions of pollination whether they get any nectar or not, as I have ascertained.

The lack of seed in the June or early July crop is generally attributed to the lack of bumblebees at that time, and rightly so, in my opinion. Occasionally, however, the farmer is surprised to find a paying amount of seed in his first crop. This happened in Illinois in 1906 and again in 1907 in various counties in all parts of the state, as I have learned from correspondence and from personal conversation with clover growers at the State Farmers' Institute and elsewhere. This early seed ran one to two bushels to the acre; some of it was put on the market in Quincy, Ill. Only two farmers offered any explanation for the production of clover seed at this untimely season, and they laid it to a "miller" that pollenized the flowers by night unobserved. This miller I am not acquainted with; perhaps the honey-bees pollenized the flowers.

Ordinarily, however, we do not expect to get seed from the June crop; and by midsummer there are always enough bees to pollenize the flowers. The failure of the seed crop need not be laid to lack of pollination as yet. In the future, if bumblebees are constantly destroyed we may be obliged to cultivate them artificially—and this can be done, if necessary for the welfare of clover. The indiscriminate killing of bumblebees should be stopped. They are the best friends of the clover grower.

2. The seed crop is diminished to some extent by various grasshoppers, beetles, and caterpillars that eat the blossoms here and there, and sometimes the green seeds. They prevent pollination and destroy developing seeds in some measure, but can scarcely be guarded against, and need no special consideration.

3. There are, however, three insects that must be guarded against if one wishes to raise a good crop of seed. These are the seed-midge, the seed-chalcid, and the seed-caterpillar. When clover blooms well, and there is good weather, the failure of the seed crop is to be charged to these three insects, the last of them being the least to blame, as a rule. All three can be controlled by simple methods described later, the most important of these being the early cutting of the hay crop.

It seems curious at first sight that an unusually large yield of seed should follow the ravages of the clover leaf-weevil. Yet this has occurred in several instances. Webster observed the fact in Ohio. The explanation is simple, however, in my opinion, for the weevil, when a pest, consumes enough leaf tissue to delay the growth of the plant materially, taking the seed crop out of the reach of its worst insect enemies. The result is the same as that obtained by the seed growers who pasture the clover in May or early June.

Early pasturing or cutting is the secret of a good seed crop, as the growers in New York, Ohio, Michigan, Canada, and elsewhere have found. The reason for the practice is not universally known, however, as is evident from the inadequate explanations that have appeared now and then in agricultural publications. For example, Shaw says (Clovers, etc., p. 103), "Experience has shown, further, that, as a rule, better crops of clover seed may be obtained from clover that has been pastured off than from that which has been mown for hay, although to this rule there are some exceptions. This arises, in part, from the fact that the energies of the plant have been less drawn upon in producing growth, and, therefore, can produce superior seed heads and seed, and in part from the further fact that there is usually more moisture in the soil at the season when the plants which have been pastured off are growing. There would seem to be some relation between the growing of good crops of clover seed and pasturing the same with sheep." The fact is that pasturing gives a good seed crop for the reason that it delays the heading of the plant until a time when the seed-midges and seed-chalcids are no longer on the wing and laying eggs. When precautions are not taken against these pests, they can be counted upon every year to destroy most of the clover seed. In this region the midge and the chalcid eat from 50 to 75 percent of the red-clover seed every year without hindrance. The farmer gets only what the insects leave. If he gets two bushels of seed to the acre, the insects have already eaten from two to six bushels off the same acre.

CONTROL OF CLOVER INSECTS

The insect pests of clovers are but seven, and they are within our control if we choose to control them. Moreover, they can be controlled by means that interfere little, if any, with usual farm practice; and the methods of control do not conflict with one another, but are essentially the same for all the clover pests,—referring especially to those of red clover.

The worst of these to deal with, where it occurs injuriously, is the root-borer. If it is very destructive in spring, plow the clover under, for this insect has quite its own way. The other pests can be disposed of without sacrificing the plant.

If the hay crop is threatened seriously in spring by the leaf-weevil or the clover-louse, pasture it or clip it back in May; otherwise, cut the hay as early as possible, in order to insure a good second growth. Usually, however, these two insects are subdued by natural agencies, in spite of their abundance.

To get rid of the worst of the seed insects, pasture or clip back in May or early June; or else cut the hay as soon as possible—as soon as it is fresh in bloom, or earlier.

Cut red clover, or pasture it lightly, in the latter part of the first season, as this goes far to reduce the number of insect pests in the same field the second year, and does not injure the clover if done intelligently. Destroy volunteer clover, which is a rich nursery for all kinds of clover insects. It can be cut most conveniently with the rest of the clover—twice a year.

Do not permit red clover to run for more than two years in this region, where it is, for agricultural purposes, a biennial.

CLOVER SEED-MIDGE

Dasyneura leguminicola Lint.
(Cecidomyia leguminicola)

This widely distributed pest, abundant in clover fields, prevents the formation of seed. At the time of blossoming, the florets affected by this insect remain for the most part green and undeveloped, and their ovaries are hollowed out and empty, or else contain each a small orange, pink, or whitish maggot. Having entered the flower-bud, the maggot consumes the fluid contents of the ovary before the bud has a chance to open. Hence the term *bud-midge* would be even more appropriate for this insect than that of *flower-midge*—recently proposed by Webster.

The maggots develop into delicate little red-bodied flies, which are so small as easily to escape observation, altho they are very abundant in clover fields at certain periods of the year.

Distribution.—The clover seed-midge has been reported as destructive in Vermont, New York, New Jersey, Pennsylvania, Delaware, the District of Columbia, Virginia, Ohio, Illinois, Iowa, Michigan, Wisconsin, and Nebraska, and doubtless occurs in other states in which clovers are grown. It does great damage in the province of Ontario, Canada, and, according to Miss Ormerod, is also found in England. In Illinois, the pest was observed as long ago as 1878 or 1879 (Fifteenth Rep. State Ent. Ill., p. 3).

Food Plants.—The chief food plant of the species is red clover, but white clover also is affected. The published statement that alsike clover is exempt from attack is incorrect, the writer having reared the midge from alsike. This clover is not badly infested, however, probably because it forms its heads three weeks later than red clover, at a time when there are but few seed-midges on the wing. For the same reason mammoth clover ought to escape severe attack, and such is said by one writer to be the case (*Insect Life,* Vol. V., p. 74). An implication to the contrary, however, is found in another publication (Bull. 116, Mich. Agr. Exper. Station, p. 55). I have had no personal experience with the midge on mammoth clover, but would point out the pos-

sibility that the injury in Michigan was done by the seed-chalcid rather than by the seed-midge.

Alfalfa is not yet known to be a food plant of this insect.

Descriptions.—The egg is barely visible to the naked eye. It is elliptico-cylindrical in form, at most 0.3 mm. long and 0.075 mm. broad, with the shell smooth and transparent. The color is at first a uniform watery yellow, but soon an internal orange spot appears, and finally the egg becomes orange thruout.

The larva (Pl. I., Fig. 1) is a footless maggot, orange-red, pink, or almost white, 2.3 mm. long and one third as broad, when full grown, with the surface of the skin minutely granulate. It has thirteen segments behind the head, and, like other cecidomyiid larvæ, bears nine pairs of respiratory tubercles, situated respectively on segment 2 and segments 5 to 12 inclusive. All these tubercles are lateral in position excepting the first and the last pairs, which are dorsal and posterior on their respective segments. A peculiar organ known as the *sternal spatula* may be detected lying against the ventral face of segment 2, and the form of this organ (Pl. I., Fig. 2), while subject to some variation, is sufficiently characteristic to distinguish this larva from that of the clover leaf-midge, the only other insect with which it is likely to be confused.

The cocoon, made by the larva, is oval in form, 2 mm. long, and composed of silken threads. It is difficult to find out-of-doors owing to its being covered with particles of dirt. The pupa, described in some detail by Comstock, is pale orange, with brown eyes, a pair of short conical tubercles on the front of the head, and a rather long horn near the base of each wing; the antennal sheaths of the cast pupal skin curve outward like the handles of an urn.

The appearance of the female midge is well shown in Figure 3, Plate I. When on the wing, she is nothing but a filmy speck, that easily eludes the vision. After alighting, her red abdomen and long threadlike legs catch the eye. Under the microscope, the head is seen to be black, and the antennæ yellowish red, with sixteen—or even seventeen—sessile segments. The sides of the thorax are reddish brown; above, most of the thorax is black, but two small posterior lobes are brownish red; the halteres are reddish yellow. The wings are transparent, closely set with short, curved, dusky hairs, and strongly fringed posteriorly with long paler hairs. Legs slender, reddish brown, the segments becoming darker distally. The abdominal segments 1 to 6 are salmon-red above, mixed with yellowish beneath; dorsally each of these segments is banded with black scalelike hairs, which rub off easily. Segments 7 to 10 of the abdomen form the pale yellow ovipositor. The insect, with ovipositor retracted, is 1.8 to 2 mm. in length, and with the ovipositor extruded, 6.2 mm. The antennæ are 0.8 mm. in length.

The male resembles the female, but bears a pair of conspicuous clasping organs at the end of the abdomen and has but fifteen antennal segments, all but the first two of which are pediceled.

We have no other midge that I know of in a red clover field that may be mistaken for the seed-midge, tho in Europe the leaf-midge was originally described from red clover. Both midges affect white clover, however, but can be distinguished by the characters given on page 172.

Life History.—In central Illinois, the clover seed-midge winters as a full-grown larva, or as a pupa, in the soil of the clover field or in dead clover heads. A few warm days and a little rain bring the larvæ to the surface of the ground a few days after the red clover has started on its second year's growth. Thus in 1907, in Urbana, the first new leaves of red clover appeared March 19—a little earlier than usual—and the orange-colored larvæ of the midge were found on the ground from March 25 to April 4, inclusive, being most numerous March 30 and April 2. They are by no means abundant, however, at this time in a clover field of the second year, and would not be present at all but for the precocious development of some clover heads during the preceding season. Some of these larvæ make a cocoon and some do not. In either event the larva contracts in length and its integument hardens and becomes duller in color, forming a *puparium,* within which the pupa develops. One larva, found March 25, 1907, made a cocoon March 30, from which a female midge emerged April 12 or 13. A second larva, taken March 30, formed a cocoon April 2 and gave a female fly April 21. Both of these flies were reared indoors, it should be said. Out-of-doors, midges were not found until May 15, but were common May 23 (at which date oviposition was in progress) and attained their maximum numbers May 30. This season was a late one, however, owing to continuous cold weather in April, and in the years 1903 to 1906 inclusive the dates of maximum abundance were May 24 and 25, the time when young green clover heads also were most numerous. The larvæ work in the heads during June and the first week of July, and leave the heads when full grown and go to the ground to pupate. Our earliest date for the emergence of larvæ from the heads is June 20. Most of the larvæ emerge about June 30, tho not a few wait as late as July 8. The pupal period at this time is three weeks or more, and the flies of the second generation are most abundant in the last week of July and the first two weeks of August, tho scattering individuals emerge at almost any other time between the middle of July and the first of September. The egg period in early August is three days, varying a few hours, more or less, according to temperature. Most of the damage to the seed crop is done during the last two weeks of August and the first two weeks of September, when the larvæ are most numerous in clover heads. Most of these larvæ pass the winter as larvæ or pupæ, to emerge as flies the following May. A few larvæ, however, attain their growth early enough to produce flies in early September or even later, out-of-doors. Under the sheltered conditions of the insectary, but without artificial heat, flies appeared as late as October 10; and in a warm room flies will emerge from clover sod thruout the winter. It appears that the few flies of late September do not succeed in propagating their kind in this latitude, owing to the direct

effect of frost on the flies, but especially to the death of green clover heads before any larvæ therein can attain their growth. It is possible, however, that flies of early September produce larvæ capable of surviving the winter.

Thus there are in central Illinois two full broods of the seed-midge each year and a feeble third generation of flies, which belong essentially to the May brood of the next year. In the literature we find that maggots of the seed-midge emerged in immense numbers from clover heads in Washington, D. C., on May 23, 1880. This date would be one month too early for such an occurrence in this part of Illinois, where May 23 is ordinarily the time of maximum abundance of the first generation of flies.

Habits.—The eggs are laid always in green flower-heads, and chiefly during the warmer part of the day. With the aid of a hand lens, the process of oviposition can be observed, the female being frequently too busy to pay any attention to slight interruptions. The last four segments of the abdomen of the female are elongate like a telescope, forming a slender tapering ovipositor, twice as long as the remainder of the body and as flexible as a whip-lash. Standing on the outside of a green clover-head, the female inserts this organ among the florets and works it deeper and deeper until it can go no farther. The sensitive tip of the sinuous ovipositor finds a suitable spot for an egg and the female becomes quiet until the egg is laid. The entire process of egg-laying requires usually five minutes, and often ten to fifteen minutes. Tho the same female may lay several eggs in one clover head, she appears to make it a rule to distribute her eggs among a good many plants. Many females may, of course, oviposit in the same head, with the result sometimes that more larvæ hatch than can possibly find food. Thus in one head of eighty florets the writer found 106 eggs. Once in a while an egg is laid on a petal or on the calyx itself, but almost always it is glued to one of the hairs of the immature calyx, the glue often forming quite a perceptible mass. This is contrary to a published statement that the eggs "do not appear to be glued to the hairs."

The newly hatched larva has only one way of entering the ovary of a flower, namely, by squeezing in between the unopened petals, as Comstock said. Once inside the flower-bud, the maggot, incapable of biting any solid substance, sucks the fluid contents of the ovary, destroying the ovule or ovules. An affected floret presents externally a healthy appearance but the petals do not expand, except rarely. They remain fresh and pink until after the maggot leaves the bud, but eventually fade and wither away without opening.

The simplest way to get specimens of these larvæ is to collect clover heads that are partly green and partly in bloom, and to shake them up a little, when many of the larvæ will squirm their way out of the buds. The maggots often occur in great numbers on the bed of a hay wagon or the floor of a barn. In a tight glass jar of clover heads all the larvæ present will emerge, and the precise amount of infestation can be ascertained.

Tho the full-grown larvæ may simply drop to the ground, as other writers have stated, they frequently wriggle their way down along the stem of the plant, when the latter is wet with rain. Indeed, the larvæ, even when full grown, will not emerge if the air is too dry. Cecidomyiid larvæ in general require considerable moisture for their development and are very sensitive to the influence of humidity. Dryness causes the seed-midge larvæ, when on the ground, to squeeze themselves into crevices in the soil and to contract the body and become motionless, as if for pupation. Even then, however, moisture will repeatedly revive them to a condition of wriggling activity.

The period of pupation is lengthened by dryness and shortened by moisture. Prolonged dryness kills both larvæ and pupæ. Out-of-doors the flies do not emerge during a dry spell; continuous dry weather will delay their appearance as much as two weeks; but they may be expected to appear after a rain, in the appropriate part of the season. In the insectary, the emergence of the flies can be similarly controlled by moisture, as G. C. Davis has already noted.

Riley states that the pupa works itself thru its cocoon and to the surface of the ground when about to give forth the fly.

Autumn finds larvæ of various sizes in the clover heads, in central Illinois. Most of the larvæ become full grown and go to the ground in September; the rest remain in the heads and either finish their growth or else succumb to frost. In spite of frosts, full-sized larvæ may be found in the heads as late as the middle of October. October 28, 1907, we found in clover heads several larvæ which were so small (0.8 mm. in length) that they must have been derived from late September flies, and they were altogether too small to survive the imminent death of their food plant.

The recognized injury done by the seed-midge to red clover occurs during the second year of the plant, and the amount of injury increases the longer the plant is allowed to run.

Vigorous plants, however, form heads during their first year, and in these premature heads not a few larvæ of the seed-midge are to be found in autumn.

Natural Enemies.—The chalcid, *Bruchophagus (Eurytoma) funebris* How., at first suspected of being parasitic upon the larva of the seed-midge, is now known to destroy the seed instead of the larva, taking what the seed-midge leaves.

We have reared from clover heads containing larvæ of the seed-midge two as yet undetermined species of the chalcid genus *Tetrastichus.* These are possibly the same two that are mentioned by Webster as having been reared directly from both larvæ and pupæ obtained about Lincoln, Neb., in December. In Delaware, Sanderson bred from larvæ of the seed-midge, in October, 1899, and in June, 1900, parasites determined by Ashmead as *Tetrastichus carinatus* Forbes and *Torymus.*

Another parasite of the seed-midge is *Anopedias error* Fitch, of the family *Platygasteridæ,* a minute black species, about which almost nothing has been written since Comstock, in 1880, reported it as emerging from the cocoon of the clover seed-midge.

An energetic enemy of the seed-midge is the common flower-bug, (*Triphleps insidiosus* Say), as was found some years ago by Dr. Forbes. I have repeatedly found a nymph or an adult of this bug with its beak thrust into a seed-midge larva or fly.

Control.—It is by no means necessary to abandon temporarily the raising of clover seed on account of this insect, as was once proposed. The most effective and most practicable preventive is that given by Comstock, namely, to cut the first crop of clover as early as possible, in order to secure a good seed crop at the expense of a slight reduction in the hay crop. The good results of this method are frequently obtained, unconsciously, by farmers who make it a rule to cut their clover near the 17th of June. The writer was once sent by our State Entomologist to examine injured clover on the farm of A. E. Myers, at Millbrook, Ill. (Kendall Co.). At that place, August 19, 1903, there were twenty acres of red clover in full bloom, with the heads well filled with sound seed, with few green heads, and with almost no sign of the seed-midge; no eggs were found and only two midges were seen during an extensive search. This clover had been cut a few days before June 25. Across the road was another field of red clover, similar in history to the first except that it had not been cut until between July 4 and 10. Here none of the clover was in bloom, all the heads were green, and almost every head was loaded with eggs of the seed-midge; often there were more eggs in a head than there were florets. The flies were abundant also, and were still ovipositing. In this instance, a difference of two weeks in the time of cutting meant all the difference between almost complete immunity and heavy infestation.

Early cutting (1) results in the drying up of the food plant and the undeveloped larva, and (2) hastens the development of the second lot of clover heads, so that the midges of the second generation find but few green heads in which to lay their eggs.

The proper date for early cutting depends, of course, on latitude, weather, and other considerations. It should be not later than June 17 in central Illinois, and need not be earlier than June 7. Clover that is cut too green does not cure well, but the cutting need not be done until the field as a whole is fresh with bloom, tho it should not be delayed until the flowers have withered. A clover head half red and half green means that the seed-midge is present (or else the seed-caterpillar), and the grower who will take the trouble to study the habits of the midge will be able to cut his clover at just the right time to get rid of the seed-midge without losing much of his hay crop.

Similar results may be had by mowing back the clover as early as the middle of May, in Illinois and Ohio. This delays the heading enough to escape the second brood of flies.

Pasturing in spring and early summer exterminates the midge and yet insures a good crop of seed, so far as this insect is concerned. This method, as recommended by Dr. Fletcher, has been adopted with great success in Ontario, Can. There the first crop is pastured to cattle or sheep until the beginning of June but not later than the middle of that

month. In Michigan, also, the same method is successfully employed by dairymen, the clover fields being pastured until the 10th or 15th of June. (G. C. Davis.)

Contrary to what might be anticipated, the seed-midge neither flies far nor is carried far or in large numbers by the wind. Most of the midges that emerge in a clover field stay there and lay their eggs there. If the wind blows they cling to the clover plants or to the ground, or take but short and occasional flights. The direction of flight is, to be sure, determined by the wind if the wind is strong, and the midges are certainly disseminated more extensively by the wind than by their own powers of flight. Nevertheless, the number of midges carried from one field to another by the wind is, in the experience of the writer, comparatively small. For example, most of the midges in a given field of second-year clover on May 25 came forth in that field and were the offspring of the few midges that entered the same field during the latter part of the preceding year. Hence it would seem to be a wise procedure to prevent the sporadic heading of first-year clover by mowing it back a few weeks after the oats (or other small grains) have been harvested, at a time when the growth is vigorous, but yet sufficiently early to permit considerable further growth before frost sets in. This cutting need not injure the clover. In this state, red clover is not infrequently cut in the latter part of the first season, for a light hay crop, or to prevent premature seeding, and in the good growing season of 1907, some first-year clover hay (mixed with stubble) was put on the market. This cutting impairs neither the hay crop nor the seed crop of the ensuing year, provided it is done early enough to allow the plants to recover before winter. Volunteer clover should always be cut, as it affords a rich nursery for all kinds of clover insects.

Where clover and timothy are mixed, early June cutting will, in this latitude, sacrifice the timothy. To obviate this, pasture lightly or clip back the growth in May. This treatment, as Webster states, brings both the first and the second blooming of the clover too late for the destructive work of the midge, and the hay crop as a whole sustains no loss.

In a few reported instances, larvæ of the seed-midge have been found mixed with clover seed in bulk, and the theoretical danger of sowing such larvæ along with the seed has been pointed out. While we have no direct evidence as to the reality of this danger, it would be well, on general principles, to kill such larvæ, by drying them up under a gentle heat, which is said not to injure the seed, or by fumigation with bisulfid of carbon.

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CLOVER SEED-CHALCID

Bruchophagus funebris How.

This abundant and energetic chalcid, formerly presumed to be an enemy of the clover seed-midge, is now known to be itself one of the worst of the clover pests. Instead of being parasitic, like most of the chalcids, it eats out the clover seeds and reduces the seed crop materially.

The adults—little, compact, black, flylike insects—are common on clover heads that are fading and ripening. Seeds containing the larvæ of this chalcid become brown, brittle, and hollow, and when the clover is threshed, the empty shells left by the adults are swept away with the chaff.

Not until 1896 was this ubiquitous insect suspected of being a clover pest, and up to the present time its life history and habits have remained almost a blank, except for what E. S. G. Titus has written. The present account makes considerable additions to the knowledge of the subject.

Distribution.—Vermont, Rhode Island, New York, Delaware, District of Columbia, Virginia, West Virginia, Ohio, Indiana, Illinois, Michigan, Kansas, Mississippi, Minnesota, Colorado, California, Oregon, and Washington. Most of these records are from Titus, who reared the insect from clover heads obtained from various states.

Food Plants.—Red clover is the chief food plant, tho crimson clover is badly affected, according to Hopkins. Alfalfa is another food plant, but one of minor importance in my experience. I have not found the chalcid on white clover, but have seen the adults on mammoth clover.

Injury.—It was A. D. Hopkins who found that this chalcid eats the seed, instead of being a parasite upon some insect.

The larva requires a seed that is going to grow, and this need is provided for by the egg-laying habits of the female. She does not lay her eggs in green heads, but selects, primarily, heads that have just

begun to wither, and, secondarily, heads that are in full bloom. Sometimes I have seen her trying in vain to thrust her ovipositor into a seed that had hardened. The young larva feeds upon the semifluid albumen of the cotyledons of the seed; as the seed hardens, the jaws of the larva harden also, and at length the larva has eaten out the interior of the seed, leaving only a thin shell. Externally, an affected seed looks unhealthy. Instead of being blue, or clear yellow tinged with red or purple at the end, and plump, it is dull brown, often misshapen and a little undersized. At threshing time some of the adults have issued, leaving only the shells of the seeds, and these shells blow away, making an unaccountable shortage in the yield; other seeds, that still contain the insect, may remain behind with the sound seeds, but are of course good for nothing. These seeds that contain the insect are not necessarily so light that they blow off with the chaff, as one writer has assumed; many of them, if not most of them, are heavy enough to stay with the sound seeds, as I have often found. The empty shells are swept away. From newly threshed seed the adults may continue to emerge in swarms, as R. H. Pettit noticed. Thus the yield of seed is reduced in amount, and part of the yield made valueless, by this insect.

August 1 we examined 49 seeds taken at random, and found 35 to be sound and 14 to be infested by the chalcid; of the latter, 3 were empty, 6 contained each a larva, 4 a pupa, and 1 an adult. Titus has found seed injured to the extent of 40 to 85 percent, with an average of 50 percent to the head.

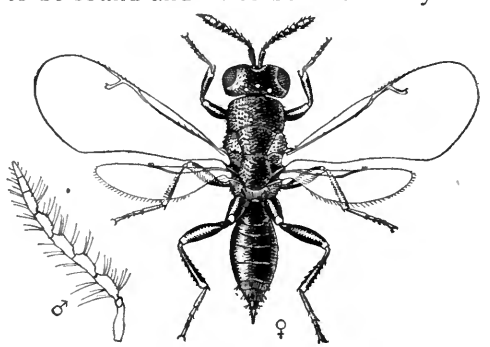

FIG. 1.—Clover Seed-chalcid, *Bruchophagus funebris*; adult female. (Webster, Circ. 69, Bur. Ent., U. S. Dept. of Agriculture.)

Without examining the seeds there is no way of telling whether the chalcid is present or not, for the rest of the plant shows no indication of the presence of the pest.

Stages.—The adult (Fig. 1) is a minute, compact, flylike insect, mostly black, but with parts of the legs yellowish brown. It is small—the female being 1.9 mm. in length and the male 1.7 mm.—yet its actions on a clover head are so characteristic that one who has made the acquaintance of the insect can recognize it at once. Apart from its natural surroundings, however, one must look to certain minute details of structure in order to determine the species.

In the genus *Bruchophagus* the marginal vein is linear and not longer than the stigmal vein; the mesonotum is umbilicately punctate, and the abdomen ovate, pointed, and compressed in the female. The male resembles the female but lacks the point to the abdomen, and the

abdomen is shorter than in the other sex; while the male, unlike the female, has oval funicle segments and long antennal hairs.

The male of this particular species, *funebris,* is black and non-metallic. Eyes dark brown, antennæ almost as long as the thorax; flagellum of eight segments, there being five in the funicle and three in the club; the funicle segments have each a short apical peduncle, and all but the first of these segments have either two or three whorls of yellowish hairs—usually three on the second segment of the funicle and two on segments three to five. The knees, anterior tibiæ, and all the tarsi are light yellowish brown. The stigma of the wing gives off a feeble branch. The abdomen, joined to the thorax by a short, stout peduncle, is small, being less than half as long as the thorax, and its fourth segment is the largest.

The female is like the male in coloration but is larger, with these distinctive characters. Antennal segments not petiolate, and without the long hairs; flagellum of nine segments, the funicle having six and the club three. Abdomen not pedunculate, longer than the thorax, with the fourth and fifth segments short and subequal, and with a light brown pointed extremity—a part of the ovipositor.

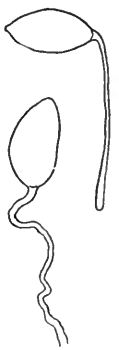

FIG. 2.—Clover Seed-chalcid, *Bruchophagus funebris,* eggs. Greatly enlarged.

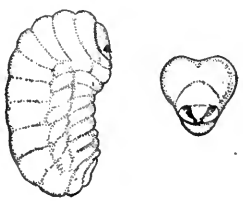

FIG. 3.

FIG. 4.

Clover Seed-chalcid, *Bruchophagus funebris*: Fig. 3, larva, and head at right; Fig. 4, pupa. (Webster, Circ. 69, Bur. Ent., U. S. Dept. of Agriculture.)

The egg (Fig. 2) is broadly elliptical to ovate in form, ending anteriorly in a small papilla and prolonged posteriorly as a slender tube, at least twice as long as the egg proper, which averages 0.26 mm. in length. The egg when laid is translucent whitish, and smooth; within a day, the appendage shrinks and turns brown.

The maggotlike larva (Fig. 3) is white, stout, and footless, with a small head; length, when full grown, 1.5 to 2 mm. The larva shows few distinctive characters, tho it is stouter and less active than parasitic larvæ of the same family.

The pupa (Fig. 4) is for a time white, but darkens as the color of the imago develops; length 1.9 mm.

Life History.—In 1904 and 1905 we made daily observations on the number of adults emerging from clover heads collected thruout the season and kept in large glass jars—each lot having been collected at one time and place. The observations when plotted on coordinate paper showed several new things.

Beginning April 14, there was a gradual increase in the number of emergences up to June 6 and 12; then a rapid decrease to July 6; afterward a sudden rise from August 4 to a high maximum August 10, followed by a rapid drop to August 24, after which date adults issued constantly, but in moderate numbers, until October 15. Out-of-doors the adults do not begin to emerge until about May 15, as a rule, and in 1907 no adults were seen until May 23, tho the clover fields had been searched almost every day for them. The June and August dates of maximum emergence in the insectary agreed with the dates of maximum abundance in the field. One year, however, I found the chalcids common July 6 to 19, and very common about July 15, tho in most years there are but two times of greatest abundance, and these are when faded clover blossoms are most numerous in the fields of cultivated clover. Some adults can be found, however, almost any day in the season from May 15 to October 15, or later, especially on volunteer clover, where they can always find heads in just the right condition for oviposition.

The insect passes the winter inside the seed, on the ground. The seeds that we have collected and examined in early March contained larvæ only; in late autumn the seeds taken from dead clover heads on the ground contained many larvæ and now and then a pupa. Evidently the species winters chiefly, if not almost entirely, as a larva, in this region.

As the first period of egg-laying extends over a month or more, there is a corresponding range in the time of emergence of the second lot of adults. Thus, clover heads collected June 18 gave adults June 21 and every day from July 4 to July 20.

More than this, there occurs a surprising extension of the period of emergence. For example, heads collected June 21, 1904 (Urbana, Ill.), gave adults June 24; July 2, 4, 5, 6; August 9, 10, 11, 12, 13; then no more until the next year, 1905, when more adults issued May 27, 30, and June 5. Thus the last adults appeared almost a year later than the first ones—all these from eggs laid inside a period of one month. One to nine individuals issued on each of these dates, and the majority issued during the first year.

Compare this record with the above: Heads collected June 28, 1904 (De Kalb Co., Ill.) gave adults (in Urbana) July 2 (5 individuals); August 8 (1), 12 (4), 15 (1), 19 (1), and no more until 1905; then adults issued May 30 (2), 31 (2); June 1 (11), 2 (2), 3 (2), 5 (11), 6 (24), 7 (8), 8 (3), 9 (9), 10 (4), 12 (35), 13 (10), 14 (12), 15 (18), 16 (8), 17 (8), 19 (7), 20 (2), 22 (2), 24 (2), and none thereafter. Here, the great majority failed to emerge until the following year. Usually it is the other way.

By July 15 or a little earlier, new eggs begin to be laid in the new growth of red clover—the seed crop. We collected an immense number of clover heads July 28, 1904, which gave adults as follows: August 5 (many), 7 and 8 (194 individuals), 9 (42), 10 and 11 (13), 12 (103), 13 (23), 14 (6), 15 (31), 16 (6), 17 (2), 18 (1), 19 (3), 22

(8); then no more until 1905, when a few issued May 24 (2), 29 (3), June 5 (1), 7 (1); then no more—observations ceasing August 8. In this case, the majority emerged near the middle of August and the minority waited until the next year.

Taking heads collected still later in the season—August 26, 1904—these gave imagines August 30 (a few), 31 (a few), September 1 (few), 2 (few), 4, 5, 6, 7, 8, 9, 11, 12, 14, 15, 16, 17, 18, 19, 20, 21, 23, 25, 26, 29, October 6 (one individual on each of these last dates, with two exceptions); then, in 1905, May 12 (5), 16 (many), 19 (many), 20 (8), 23 (1), 26 (1), June 2 (1), and no more up to September 1, when the daily observations were discontinued.

Heads collected September 7 gave a few adults in September and October, but very many more in the following April and May.

Heads collected September 16, October 3, 17, and 27, gave no adults until the following April, May, and June, when large numbers issued.

In the last three instances most or all of the adults did not issue until the next year. Thus the time of emergence is delayed in proportion to the lateness of oviposition.

These records are by no means exceptional; they are typical; those given here were selected from some twenty as being the most complete and most significant for present purposes.

To summarize: The May and June adults lay their eggs in the first growth of second-year red clover, and most of the adults derived from these eggs appear in July and August, but some of them do not issue until the following May or June. The July and August adults lay their eggs in the second growth, and some of the adults from these appear during the same season; the rest not until the following year. The later the eggs are laid the larger the proportion of individuals to lie over until the next year. The adults have two times of greatest abundance, falling near June 12 and August 12 respectively. This does not mean only two generations, however, but, instead, two lots of individuals. The first lot (June 12) is derived from eggs laid thruout the previous season. The second lot (August 12) has no accessions from the previous year, but is, nevertheless, composite in its nature, for it consists of adults of both the second generation and the third. I have traced as many as three generations per year, and there is clearly a possibility of four. The fact that some members of each generation lie over until the next year complicates the study of the life history.

At first, it seemed to me at least possible that the prolongation of the period of emergence might really be due to re-oviposition in the old clover heads, even tho the chalcids had been removed every day as fast as they came to light and no copulation had been observed. This assumption was dismissed, however, after being tested, for the seeds were all too dry and hard to be penetrated by the ovipositor or to serve as larval food. There remained only the possibility that some chalcids had emerged soon enough after the clover heads were collected to

find seeds soft enough for oviposition, but this possibility was too slight to account for the immense number of late-emerging chalcids. Furthermore, any larvæ from eggs laid in the jars of clover heads would soon be disposed of by the drying and shriveling of the green seeds. I could not find any evidence of re-oviposition.

There is one source of possible confusion that must be guarded against in studying the life history of this chalcid. There emerges from the clover heads, along with *B. funebris,* another chalcid, *Tetrastichus bruchophagi* Ashm. MS., so named upon the assumption that it is a parasite of the clover seed-chalcid. This *Tetrastichus* is so much like the *Bruchophagus* in general appearance that it might hastily be mistaken for the latter, tho many differences between the two appear under the microscope.

Habits.—While the clover heads are green, in spring, few if any of the seed-chalcids will be found; but when they begin to turn brown, the chalcids appear on them. The males appear four or five days earlier than the females, and both sexes frequent the clover heads, but the males do not rush about and explore the recesses of the clover head in the way that the females do.

On warm sunny days the chalcids are most active, and then most of the eggs are laid. On rainy days both sexes remain quietly in the clover heads. They make their home among the florets, and there, at length, their dead bodies are to be found.

Brown ripe clover heads give the female much trouble, for she can not insert her ovipositor into a hard seed; green heads she passes by; florets in full bloom receive some attention and some eggs; but most of the eggs are laid in florets with withering corollas.

The males are quick to fly when one brings a hand lens near them, but the busy females occasion the observer less difficulty. The female squeezes in and out among the florets, often working her way deep into the flower head, so that one must cautiously spread the florets apart in order to follow her movements. Every now and then she stops to clean her antennæ with the front legs, or her wings and abdomen by passing the hind legs backward. With the tips of her palpitating antennæ she keeps touching the florets, especially the calyx, as if testing it. At length she proceeds to lay an egg, and usually pierces the side of the calyx tube, tho sometimes she stands on the top of the calyx, between the calyx lobes and the corolla. Bending the end of the abdomen forward under the body, she releases the long needlelike ovipositor and thrusts it into the calyx; then the abdomen recovers its normal form, but the ovipositor, at right angles to the body, remains inserted in the wall of the calyx, and is pushed and wriggled until its tip has entered the young seed. After three to twelve minutes the organ is withdrawn and rapidly slipped back into place. Sometimes a tiny colorless drop of fluid is seen at the tip of the ovipositor just before it is thrust into the calyx.

The observer, having identified the floret during the process of oviposition, can then pry it out with a knife and carry it back to be

dissected under a microscope, if he wishes to find the egg. The egg is found inside the seed in the semifluid albumen. Being translucent and almost colorless, the freshly laid egg transmits the pale green color of the surrounding seed tissue and is inconspicuous; but as one dissects the albumen carefully, the egg comes out like a lump of jelly, soft and delicate but sufficiently elastic to keep its form. The egg varies considerably in shape and must assume its definite form after leaving the ovipositor; for the body of the egg is wider than the channel of the ovipositor, and no distension of the organ is seen during oviposition. It is to be inferred that the egg passes thru the ovipositor in the form of a long thread, the body part of the egg entering the seed first and at once expanding. The usual position of the egg in the seed, with the end of the appendage near the seed coats and the body of the egg farther away, indicates that the body entered first. The appendage probably serves as a reservoir for some of the egg-contents while the egg is going thru the ovipositor. This appendage is empty in the freshly laid egg, and within a day after the latter is laid the former shrinks and turns brown—then affording a ready means of locating the egg. Without a careful dissection this delicate appendage will be missed.

The seeds in which the eggs are laid look sound and healthy and contain no other insect—so we have always found.

The egg, dissected out of a seed, can be kept for some time in a glass tube, upon a piece of moist black paper or a fragment of albumen taken from the seed, and can be examined daily under the microscope in order to determine the egg period. We kept eggs in this way for thirteen days, after which they appeared to be dead. Another way is to take a large number of seeds from florets in which the females were seen to oviposit, and to dissect these at successively longer intervals from the time of oviposition, making sure that there is not more than one egg in each seed. By this method I found that eggs laid July 22 were unhatched and apparently sound thirteen days afterward, but then the material gave out, and I do not yet know precisely the duration of the egg stage.

The larva when full grown fills the seed, leaving only the shell intact.

The adult emerges thru an irregular hole, generally at the top of the seed (as the seed stands in the calyx). In one instance I saw such a hole in the seed when the seed contained not an adult, but a pupa. The opening was no doubt made by the larva but was probably accidental—for among phytophagous chalcids in general the exit opening is bitten out by the adult, not by the larva.

Natural Enemies.—In company with the seed-chalcid, there emerged frequently, in our jars of clover heads, a second black chalcid which might casually be mistaken for the first species, tho belonging to another genus—*Tetrastichus*. The species is *T. bruchophagi* Ashm. MS., as determined from specimens named by Ashmead himself, and obtained by Mr. R. L. Webster from Prof. Lawrence Bruner. The

specific name may or may not prove to be appropriate in its meaning. At present I know of no direct evidence that the *Tetrastichus* feeds on the seed-chalcid, but the parasitic habit of other members of the genus, and the association of this species with the seed-chalcid, in the apparent absence of other possible hosts, leads one tentatively to regard the *Tetrastichus* as an enemy of the destructive clover seed-chalcid.

Control.—All things considered, the shortage of the seed crop, as a constant occurrence, is due chiefly to the seed-midge and the seed-chalcid, in this state. Probably the midge is a little more injurious than the chalcid; at least, the larvæ of the former are a little more abundant than those of the latter.

The chalcid has not attracted the attention that it will from economic entomologists, and nothing in the way of preventive measures has been proposed except the cautious statement by Webster that the same means recommended for the midge might apply to the chalcid, and that the destruction of outstanding clover heads and the burning of chaff and stems after hulling would in all probability greatly reduce the numbers of the insect.

It is safe to say that early cutting in June would undoubtedly prevent a great amount of oviposition, and if done as soon as the field came into bloom, would not only forestall most of the oviposition, but would also dispose of any eggs or young larvæ that might already be present in the tender green seeds; for the green unhardened seeds dry out and shrivel up soon after the leaves and stems dry. Moreover, early cutting of the hay crop would hasten the maturity of the seed crop in a way to prevent most of the midsummer oviposition; not all of it, of course, for some chalcids would be on the wing whenever the clover heads ripened. It is true, however, that the life history of the chalcid has become adapted to that of red clover as it is usually cultivated, and that the two periods of maximum abundance of the chalcid coincide with those of the greatest abundance of ripening clover heads; and it follows that the methods given would largely derange this adjustment.

The fact that the insect passes the winter inside the seeds on the ground indicates plowing under as a preventive. This is ordinarily done anyway after the second year of the clover, and when done at the usual time—as early as practicable in spring—the plowing doubtless buries most of the insects beyond the possibility of emergence.

In first-year clover the chalcid lays eggs in such heads as may be present in the latter part of the season, and these heads are often numerous. Their seeds, falling to the ground, furnish no small proportion of the chalcids that appear in the same field the following May and June. It would seem wise, therefore, to clip off or pasture off the heads of first-year red clover. In fact, something of a fodder crop can be obtained in the latter part of the first season without injury to the plant, if the cutting is not done too late in the season.

Volunteer clover is always infested by the chalcid, as well as by other pests, and ought to be destroyed.

I have several times examined commercial clover seed and found some of it injured by this insect, but the inmates of the seeds always happened to be dead. There is a strong possibility, however, that new clover seed takes the living insect to the field. Such seed, if sown broadcast, would permit the adults to emerge; but if drilled in, would dispose of the chalcids, as they could scarcely make their way to the surface.

Bruchophagus funebris How.

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1904. Titus, E. S. G.—Bull. No. 44, U. S. Dept. Agr., Div. Ent., pp. 77–80.
1906. Webster, F. M.—Circ. No. 69, U. S. Dept. Agr., Bur. Ent., pp. 7–9.

CLOVER SEED-CATERPILLAR

Enarmonia interstinctana Clem.
(Grapholitha interstinctana)

In its ability to diminish the seed crop, this pest ranks with the seed-midge and the seed-chalcid. Attacking a clover head that is green or partly in bloom, the little caterpillar eats out a cavity in the head, destroying many of the unopened buds and some of the tender green seeds, and spoiling the head as a whole. When no young clover heads are at hand, the caterpillar feeds on tender green leaves at the crown of the plant.

The adult is an inconspicuous little brown moth of the family *Tortricidæ*, and may be recognized by means of its peculiar silvery markings.

Distribution.—The published records show that this insect is present in Maine, Massachusetts, New York, Pennsylvania, Washington (D. C.), Ohio, Indiana, Illinois, Iowa, Missouri, and Michigan. It probably occurs in other states. In Illinois it is well established thruout the state, holding its own every year, and becoming locally abundant now and then.

Food Plants and Injuries.—The chief food plant is red clover, but white clover is also affected, and we have reared the species from alsike. Lintner quoted a correspondent to the effect that mammoth clover was not touched by a certain insect which Lintner (Eleventh Report, p. 153) took to be the seed-caterpillar. The correspondent's letter evidently refers, however, not to this insect at all, but to the seed-chalcid. There appears to be no reason why mammoth clover should

be exempt from the seed-caterpillar, and we have actually found it on so-called mammoth, which appeared to be a cross between mammoth and the common red clover.

Hatching usually near the base of a green clover-head, the larva eats into the head, destroying the green florets as it goes. A small green head is often destroyed entirely, before it is many days old; a larger head is injured only locally at first, remaining green on one side, while the other and unaffected side may come into full bloom (Pl. I., Fig. 9). To judge from the external appearance of the head, either the seed-caterpillar or the seed-midge larva might be the author of the mischief, and both are often present at the same time. A midge larva, however, is hidden away in the ovary of a single floret, while the seed-caterpillar makes a large dirty excavation involving many florets, and is readily brought to light by tearing open the clover head. The caterpillar attacks particularly the bases of the florets, and eats everything, including the semifluid ovules; occasionally it eats a soft green seed but it does not eat into seeds that have hardened. Not infrequently two larvæ are found in the same head. Even when the direct injury is confined to a portion of a clover head, the entire head is ruined, for it at length dries up and loses the rest of its florets, leaving only the dead brown receptacle.

Less conspicuous, tho not inconsiderable, is the injury at the crown of the plant, done chiefly in September and October, by caterpillars of the same species feeding on the young leaves.

The total amount of injury by this insect is, of course, variable. In New York, Comstock once found 15 to 20 percent of the heads of red clover infested. In Michigan, Webster saw clover injured to the extent of 95 percent. In Iowa, Gillette, Osborn, and Gossard have found the severest kind of infestation. While not sufficiently abundant to attract attention, the insect is, nevertheless, the unsuspected cause of a considerable reduction in the seed crop; for the destruction of one head by a caterpillar means a loss of more than one hundred seeds.

Stages.—The egg, hitherto undescribed, is at first green, then yellowish white, and is almost orbicular as seen from above, tho it is flattened ventrally; the surface is finely granulate and iridescent. The dimensions are as follows: length, 0.275 mm.; width, 0.26 mm.; and height, 0.21 mm.

The full-grown caterpillar, 7 or 8 mm. long, has the usual five pairs of prolegs. The color varies in accordance with the nature of the food (green tissue, or red floral tissue) from dirty white, tinged with green, to orange, as in Figure 10 of Plate I. The alimentary canal with its greenish or purplish contents shows thru the translucent skin and shifts in position as the caterpillar moves. The head is dark brown and polished, caudate occipitally, and deeply immersed in the prothorax. Prothoracic shield yellowish with a brown posterior border interrupted by a median line of white; or else dark brown with a clear median line. The body bears not a few pale stiff hairs, and the

dorsal piliferous tubercles are arranged, as Comstock noted, in two pairs, those of the anterior pair being closer together than those of the posterior pair.

Comstock has already described the pupa in detail. Essentially, it is 5 mm. long, brown, with the wing-cases and the dorsum of the thorax darker than the rest. There are two transverse rows of teeth on the dorsum of all the evident abdominal segments except the last, and the blunt anal segment bears posteriorly six stout blackish excurved hooks, and several delicate hooked filaments.

The oval white silken cocoon, 10 mm. long, is usually inconspicuous on account of the particles of excrement or bits of floral tissue attached to it.

The adult (Plate I., Fig. 11), expanding only 8 to 10 mm., is a silky dark brown moth, with brilliant silvery markings that are quite characteristic. The most conspicuous marks are those that make the two parallel crescents when the wings are closed. Along the anterior border of the front wing are eight silvery marks (sometimes nine) in form and position as shown in the figure. In fresh specimens the front wings show a few patches of iridescent scales. The hind wings are dark brown, with pale fringes.

Life History.—Our field and insectary observations show that there are three generations of this species every year, without much overlapping of the broods. Here, the moths of the first generation begin to emerge from the pupæ May 15, attain their maximum numbers May 24 (along with the clover seed-midge), and disappear during the last of June. In 1907—a late season—we saw no moths until May 21, and they were most numerous May 30. The moths of the second generation appear in the form of a few scattering individuals as early as June 25, but most of them are on the wing during the third week of July, and a few battered specimens linger over into the first week of August. The moths of the third generation appear as early as August 19, become abundant by August 30, continue to emerge as late as September 12, and die off by the last of September. Some margin—a few days—should, of course, be allowed for these dates, which are here given as they appear on our note-slips.

Eggs laid September 2 hatched September 7. The larval period is from one month to five weeks. The pupal period in July is between two and three weeks. It is possible to find larvæ of various sizes at any time from the last week of May until winter sets in, tho larvæ are few and far between when the moths are most numerous.

The moths of the third brood lay their eggs at once, and these hatch in five or six days; but the further life history becomes twofold, depending on where the eggs are laid. In the insectary the moths lay their eggs preferably on young clover heads, but if not supplied with these they oviposit erratically on fresh or dead leaves or stems. Out-of-doors in September and October the larvæ occur in two situations; either in immature clover heads, or at the crown of the plant. In the clover heads active larvæ can be found thruout October, in spite of the

frost, and a large proportion of these doubtless succeed in pupating before winter overtakes them. In the insectary, pupation in October is the rule. Larvæ which hatched September 7 spun cocoons October 14, and pupated October 16. One larva pupated September 2, and the moth emerged June 27.

The fate of the larvæ that feed at the crown of the plant in autumn is rather uncertain. The earliest ones probably pupate, and some of the remainder very likely survive the winter as larvæ. We have not been able as yet to find any of the larvæ in early spring, but in Iowa, following a year of heavy infestation, Gossard found full grown larvæ under rubbish and manure, and partly grown larvæ still in the crowns of the plants, April 22, tho the number found was only 25 percent of that found the preceding autumn.

Habits.—The moths appear in spring along with the first green heads of the red clover. When disturbed they take short rapid zigzag flights and come to rest on a clover plant. In the hot sunlight they seek the shaded side of a stem or the under side of a leaf, but in the cooler and darker parts of the day and in cloudy weather they often alight in full view, and close the wings, forming a little brown triangle marked with a silvery double crescent as in Figure 11, Plate I.

The moth, upon alighting, has the peculiar habit, already remarked by others, of whirling about in a circle several times, with the head as a pivot, and then reversing the movement before settling to rest. No explanation for this performance is evident.

Osborn and Gossard have reported the moths as being especially active in early evening, when they hovered over the clover blossoms in such numbers as to form a perfect cloud between the observer and the sun.

In clover that is forming heads, nearly all the larvæ are at work in the heads, but a few are present in unexpanded leaf-buds, eating out the interior tissue.

In first-year clover that has not headed, and in second-year clover that has been recently cut, the eggs are laid, singly as usual, on young stems and leaflets at or near the base of the plant, where the larvæ hatch and remain.

In first-year clover with oats, the moths are abundant in the new growth after harvest. Such was the case in a field in Urbana August 30, 1907, at which time none of the new growth had headed. In an adjoining field of second-year clover, the heads of which were nearly all brown, the moths had disappeared, leaving the seed-chalcid in charge of the crop. In September, a good many green heads occur on first-year clover, and in these the moths lay eggs rather abundantly. Volunteer clover is always infested by the seed-caterpillar.

The cocoon is spun in a clover head or at the surface of the ground, according to the situation of the larva. Comstock gives twenty to thirty days as the pupal period, and mentions that the pupa works its way out of the cocoon before giving forth the moth. Osborn and Gossard have found the pupa-cases in abundance on the ground, from which a brood had just issued.

Natural Enemies.—We have reared several braconid and ichneumonid parasites of the seed-caterpillar which await authentic determination. The following species have been published as parasites of this host: the ichneumonid *Glypta leucozonata* Ashm. (Proc. U. S. Nat. Mus., Vol. XII., 1889 [1890], p. 449), reared in Missouri by Miss M. E. Murtfeldt; the braconid *Phanerotoma (Sigalphus) tibialis* Hald. (Proc. Acad. Nat. Sci., Phila., Vol. IV., 1849 [1850], p. 203), raised in Washington, D. C., by Comstock; and a second braconid, *Microdus laticinctus* Cress. (Can. Ent., Vol. V., 1873, p. 53), recorded from Missouri, Iowa, Canada, and elsewhere. In Iowa, Osborn and Gossard have reared the last in abundance from cocoons of the clover seed-caterpillar, and have found that it corresponds exactly with its host as regards the number and the duration of the broods.

Gossard expresses the presumption that the braconid *Bracon vernoniæ* Ashm. (Proc. U. S. Nat. Mus., Vol. XI., 1888 [1889], p. 619) is a parasite of *E. interstinctana* in Iowa, since it is associated with the latter species in marked numbers and corresponds closely with it in time of appearance.

Control.—The best remedy for the attack of the seed-caterpillar is that proposed by Comstock, namely, to cut and store the hay crop early in June (New York, Illinois, Iowa), just as advised for the seed-midge, in order to kill the larvæ while still in the heads. The hay should be handled lightly and stacked or stored as soon as possible. Osborn and Gossard have attested the value of this method, and have given these further recommendations: (1) cut volunteer clover in early June and dispose of the heads speedily; (2) do not allow clover to run for more than two years; (3) sow seed on land remote from old fields; (4) pasture clover in the fall of the first year; (5) plow an old clover field under in October or November or in early spring, then harrow and roll. These practices operate at the same time against several other clover pests.

Enarmonia (Grapholitha) interstinctana Clem.

1860. Clemens, B.—Proc. Acad. Nat. Sci., Phila., p. 351.
1881. Comstock, J. H.—Rep. U. S. Comm. Agr., 1880, pp. 254, 255.
1891. Osborn, H., and Gossard, H. A.—Insect Life, Vol. IV., pp. 56–58.
Osborn, H., and Gossard, H. A.—Bull. No. 14, Iowa Agr. Exper. Sta., pp. 166–169.
Osborn, H., and Gossard, H. A.—Bull. No. 15, Iowa Agr. Exper. Sta., pp. 260–262.
Osborn, H., and Gossard, H. A.—Twenty-second Ann. Rep. Ent. Soc. Ontario, pp. 74, 75.
1892. Gossard, H. A.—Bull. No. 19, Iowa Agr. Exper. Sta., pp. 571–589.
1896. Lintner, J. A.—Eleventh Rep. State Ent. N. Y., pp. 152–156.

PEA-LOUSE, OR CLOVER-LOUSE

Macrosiphum pisi Kalt.
(Nectarophora destructor)

This is a big, green, long-legged plant-louse that has ruined millions of dollars' worth of field peas and a great deal of red clover. It is the dominant species of its kind on these plants (Fig. 5) and can scarcely be confused with any other aphid.

FIG. 5.—Clover-louse, ***Macrosiphum pisi***, on stems of red clover. Natural size.

Distribution. — This pest was, in all probability, introduced with clover and peas from Europe, where it is widely distributed and common, tho it is reported mostly from England, Germany, France, and Italy. In the United States it has been injurious in Maine, New Hampshire, Vermont, Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, the District of Columbia, Virginia, North Carolina, Ohio, Illinois, Michigan, Wisconsin, Minnesota, Nebraska, Iowa, Kentucky, and Texas. It is widespread in Canada also, occurring in Nova Scotia and New Brunswick and westward thru Ontario.

Not until 1899 did the louse attract the attention of American entomologists; in that year an outbreak in Maryland was reported upon by W. G. Johnson. He and E. D. Sanderson have written most of the literature on the species.

Our personal observations of several years, made as independently as possible, have yielded many facts that were already known and many that are new. The present account refers especially to the insect as it occurs in Illinois. In the eastern states the insect is chiefly a pest on peas. Here, where peas are not grown extensively, it is a pest on red clover.

Food Plants and Injury.—Under the name of "green dolphin" this aphid has long been known in Europe for its injuries to peas and vetches, and in minor measure to clovers and various weeds—some forty plants in all.

In America the aphid has done immense damage to peas and clovers. It affects especially leguminous plants, but numbers also

among its food plants many weeds of diverse families. The more important of its food plants are red clover, crimson clover, field pea, sweet pea, vetches (known also as "tares"), beet, lettuce, shepherd's purse, and nettle, not to mention the rest of the weeds. Alfalfa seems to be immune from attack. Thirty sweeps of the net in red clover yielded 3000 of the aphids, while the same number of similar sweeps in an adjoining field of alfalfa gave only 30. This alfalfa was mixed with some clover, however, and observations on the few lice that could be found on the alfalfa failed to find them in the act of feeding. On soy-beans growing next to heavily infested clover, not a single louse was found. Where crimson clover is grown, the aphid prefers it to red clover, it is said.

Where peas are grown, the aphid winters in a field of clover or on weeds (as a wingless female or as an egg), and in spring is confined to these until the peas start to grow, and then it does not get to the early varieties, tho it devastates the late-sown peas. In early spring most of the aphids are wingless and remain where they happen to be, but in late spring (May 1, Delaware) and early summer there are many winged females that can go from clover to peas and start an infestation. The first aphids select the youngest leaves and shoots, but eventually the lice cover the entire plant and sap out its life, rendering it unfit even for fodder.

In Wisconsin the louse was noticed in a five-hundred acre field of peas about July 20; in less than a week all the plants were dead and brown. In Maryland in 1899, the louse destroyed peas valued at $3,000,000, conservatively estimated, and in 1900, $4,000,000 worth were destroyed.

On red clover, the youngest leaves and stems are the first to be attacked, and these wither and die if many aphids are present. Wilted leaves mark the spread of the pest over the plant. Red clover, however, can stand a good deal of this injury, and if a heavy rain happens to occur when the plant is covered with the lice, they are washed off, and the field is safe for the rest of the season. There are also numerous insect enemies and a fungous disease, which kill off immense numbers of the lice. At times a combination of circumstances occurs, however, under which the plant is killed, root and all. The natural checks upon the increase of the aphid may be insufficient; but dry weather seems to be the most important factor. Without rain the plant can not replace the sap taken by the aphids, let alone make any growth; in dry weather the fungus can not develop; and in the absence of heavy rains to wash them off the plants, the aphids thrive. In dry weather, when the plants are loaded with lice, the cutting of the clover is the last straw.

In 1903 the louse killed an immense amount of red clover, and weakened much more, in De Kalb county. Being sent there by the State Entomologist, I found on the farm of Mr. A. E. Myers, at Millbrook, August 19, eighty acres of dead clover roots in one field. Not one root in a thousand showed any signs of life, and on the ground were thousands of the cast skins of the aphid. At cutting, the lice had

been such a nuisance that the men objected to handling the crop. After cutting, the clover never revived. In neighboring fields there were many bare spots where the aphid had killed the clover locally, and in the growing clover were many centers of new infestation, due doubtless to migrant winged females. All the clover in that part of the county was more or less injured; not only old clover, but also the first-year growth. Returning to the same region the following summer, to see the consequences of the injury, I did not stay long, for it was hard to find a field of clover anywhere. The farmers reported that the clover had been "winter-killed," to their surprise, since the winter had not been a severe one and the clover had often survived worse winters. The failure of the clover had discouraged almost all of them from sowing a new crop. My personal opinion was that the "winter-killing" would not have occurred had not the plants been weakened previously by the aphid. Clover is undoubtedly injured by certain winter influences, especially by being "heaved" out of the ground by frost, but there must be taken into consideration also the inability of the plant to face the winter when it has been ravaged by such insects as the aphid or the root-borer.

Only at rare intervals has there been a bad outbreak of this species. In England, according to Kirby and Spence, the havoc wrought by this aphid in 1810 was remarkable for its suddenness. Equally unanticipated was the outbreak of 1899 in some of the Atlantic states and in Canada. In 1900 the devastation continued in places where the previous injury had been worst, and a new outbreak occurred in Wisconsin. Since then no reports of serious damage have been published, but in Illinois this aphid was locally injurious in 1903, as just described, and has menaced the red clover every year from 1903 up to the present. Heavy rains subdue the louse almost every year.

Description.—The clover-louse is noticeably larger than any of the other aphids that frequent the field, the largest females being 6 mm. from tip to tip. The green color of the louse matches that of its food plant. The legs are conspicuously long, and the tarsi, distal ends of the tibiæ and femora, as well as the tips of the cornicles, are fuscous. The antennæ are darker at the joints, with the terminal filament fuscous. The eyes are red and prominent. With this general statement we may pass to a more detailed description of the species.

The generic term *Nectarophora* is antedated by *Macrosiphum* (Pergande, Bull. 44, Div. Ent., U. S. Dept. Agr., pp. 13, 14).

With the other species of its genus, *M. pisi* has the front of the head concave, with a large pair of tubercles supporting the antennæ. The antennæ, legs, cornicles, and abdominal stylus are exceptionally long in this genus as compared with other genera of aphids. The wings are large, the third discoidal vein has two forks, and the stigma is elongate-lanceolate. The terminal portion of the sixth antennal segment is very long and bristlelike. Most of the species of *Macrosiphum* are large and frequent herbage.

On the basis of Sanderson's studies we are obliged to regard this aphid (the *N. destructor* of Johnson) as the common *M. pisi,* of Europe, described long ago by Kaltenbach.

The *alate viviparous female* (Pl. II., Fig. 1) is 4 to 5 mm. long, with an occasional maximum of 6 mm., and 1 to 1.5 mm. broad. Antennæ long, reaching to the tip of the stylus or a little beyond; first and second segments short and close to the tubercle; third to sixth segments related in length respectively as 3 : 2 : 1.5 : 4, the terminal filament of the sixth segment being three times as long as the base. Wing expanse about 11 mm. Fore wing 5 mm. by 2 mm. Cornicles slender, cylindrical, and long,—1 to 1.5 mm. Abdominal stylus half as long as the cornicles.

Sanderson gives smaller measurements thruout for the autumn winged viviparous female, it being only 3.15 mm. in length, with proportions varying a little from those just given.

The *apterous viviparous female* (Pl. II., Fig. 2) is a little larger than the winged female, ranging in length from 4 to 6 mm., and the body is more elongate and fusiform, with longer cornicles (1.25 to 2 mm.) and a longer stylus. This form also is smaller in autumn, as Sanderson has noted, with much more extensive dark brown or blackish markings on the appendages.

The *oviparous female* is apterous.

The *egg* has not been described before. It is elliptical, twice as long as broad (0.5 mm. by 0.25 mm.), and changes from saffron-yellow to shiny black one or two days after being laid.

The *winged male* is 2.5 mm. in length, with a wing expanse of 9 mm. It may be recognized by its smaller size, among other things. The color tends toward pale green or yellow. The dorsal sclerites are dark, as is also the mesosternum, and there are lateral blackish spots in front of the cornicles. Sanderson has described this form.

Our insectary notes on one pair of *M. pisi* taken *in coitu* refer to the male as being apterous.

In autumn many of the aphids normally turn yellow; in fact, some yellow individuals can be found at any time, and aphids that are diseased usually do become yellow.

Life History.—The clover-louse winters both as a large wingless viviparous female and as an egg, but the eggs are not numerous. Many of the females are killed off during the winter. The survivors are easily found under rubbish in the clover field in the first week of April and even as early as March 25, tho they are a little slow to revive. They crawl to the clover plants and proceed to suck the sap and to bring forth living young, all of which are also females; indeed, no males appear until the last of the season and no eggs are laid until then. During most of the season there is nothing but a constant succession of females, all of them born alive. Most of them are wingless, tho in any of the generations there may be some females that have wings; these also bear their young alive.

The eggs that were laid on green leaves or stems the preceding autumn hatch a few days after the red clover starts on its new growth. March 23 Mr. E. O. G. Kelly found newly hatched young on a clover plant, and egg-shells close by on old dead clover leaves. One of these aphids, kept on potted clover, produced her first young April 5, and died May 12, after having brought forth ninety young.

Mr. R. L. Webster carried thru the season successive generations derived from a single female that came from the egg March 23, and obtained (by breeding always from the first-born) as many as seventeen generations, the young of the seventeenth brood issuing September 21 to October 3. In the field, newly born young can be found as late as November 4, tho we can not name the generation to which they belong. His more important data may best be given in the form of a table.

M. pisi

Generation	Birth	Maturity	Death	Days to mature	Days of life	Number of young
1	Mar. 23	Apr. 5	May 12	13	50	90
2	Apr. 5	Apr. 25	May 12	20	37	87
3	Apr. 26	May 8	May 13	12	17	25
4	May 8	May 20	June 16	12	39	89
5	May 20	May 31	June 9	11	20	49
6	June 1	June 10	June 20	9	19	41
7	June 10	June 19	July 17	9	37	37
8	June 19	July 1	July 17	12	28	60
9	July 1	July 10	Aug. 2	9	32	63
10	July 12	July 22	Aug. 3	10	22	30
11	July 22	Aug. 3	Aug. 15	12	24	44
12	Aug. 3	Aug. 11	Aug. 16	8	13	34
13	Aug. 11	Aug. 21	Aug. 30	10	19	16
14	Aug. 21	Sept. 1	Sept. 5	11	15	8
15	Sept. 2	Sept. 12	Sept. 15	10	13	10
16	Sept. 12	Sept. 21	Oct. 4	9	22	53
Averages..... ...				11	25.4	46

The averages are worth notice. A female begins to reproduce eleven days after birth, as a rule; this accounts for the large number of generations. The average number of young is not large for an insect, for insects as a whole average at least two or three hundred eggs per female. The average given in the table is confirmed by one based upon a large number of additional observations taken thruout the season. A female is, however, capable of producing as many as 147 young, and many of the females at death have embryos of various stages in their bodies.

The largest number of young produced in one day by one female is 13, and the average number 6, in our experience; while the bearing-period of the female averages 12.1 days. In October and November the females bear but few young, but some of these females hibernate and produce more young the following year.

Our breeding experiments, it should be said, were conducted indoors, where the aphids were protected from every source of danger. Out-of-doors the mortality would probably not be so small.

R. L. Webster's continuous observations on the life history are a useful addition to our knowledge of the species. His results are corroborated by those of Mr. E. Q. Snider, who, while a student at the

University of Illinois, made a similar series of studies. He began with the first hibernating females that he could find, and traced their progeny. One of the females found April 8 brought forth the first young aphid April 17, and this acquired wings April 29. In the field I have seen winged individuals at all times up to November 10.

Five apterous viviparous females studied by Snider bore, respectively, before the end of June, 104, 108, 110, 124, and 147 young. The last number is unusually large even for an aphid.

Males and oviparous females were not found until October (with one exception—a female born September 22); and males were taken in the field October 10, 17, 20, and November 3. Copulation was observed in the field October 20 and November 3; in the last instance oviposition began twenty-five minutes after copulation ceased. Six females began to oviposit, respectively, October 18, 20, 21, 31, and November 3 and 4. One female *in coitu* October 20 laid eggs October 26 (2 eggs), 29 (1), 31 (2), November 3 (1), 4 (1), 5 (1), 6 (2), 18 (2), and no more up to December 2, when the observations ended. A female born September 22 laid an unfertilized egg October 18. A female taken in the field October 11, 1904, laid eggs October 21, which hatched March 23, 1905. The eggs have escaped the notice of previous observers. Here, the eggs are common.

Habits.—When these aphids are as yet few, they select the youngest leaves and stems of the plant, especially the under sides of the leaves; but as they increase, they spread over the plant, and may crowd together so closely that large numbers fall to the ground for want of standing room.

The rapid increase in the number of individuals is not due to any extraordinary prolificacy, but results from the rapid growth and consequent early maturity of each aphid and from the fact that almost every individual is a female.

While the aphid is growing, the moults occur at short but variable intervals, as appears in the following table made from R. L. Webster's notes.

M. pisi

No. of generations	Born	First moult	Second moult	Third moult	Fourth moult	First young
1	March 23	March 28	March 31	April 2	April 4	April 5
1	March 23	March 25	March 31	April 4	April 9	
2	April 5	April 9	April 12	April 15	April 21	April 25
2	April 5	April 10	April 13	April 18	April 21	April 26
3	April 26	April 29	May 1	May 3	May 5	May 8
4	May 8	May 12	May 15			May 20
5	May 20	May 22	May 23	May 25	May 28	May 31
6	June 1	June 3	June 5	June 7	June 9	June 10
7	June 10	June 12	June 13	June 15	June 17	June 19
9	July 1	July 3	July 4	July 6	July 7	July 10
9	July 1	July 3	July 5	July 6	July 10	July 11

Thus there are four moults, or five instars, and the mother does not reproduce until after the last moult.

Another student (J. P. Gilbert) found five moults in one instance: an isolated female, born June 20, moulted June 23, 26, 27, 29, and 30. Each cast skin was removed as soon as found, and five of them were found.

More interesting than the number of moults is the fact that the females reproduce for many successive generations without the aid of the male—a normal phenomenon among aphids, and many other insects as well—and also the fact that the young are born alive. This can easily be witnessed, as aphids are so numerous. In this species the young aphid emerges hind end first and back upward, and enveloped in a delicate membrane, which it gets rid of by means of vigorous kicking. The entire process, requiring ten or fifteen minutes, is essentially as described elsewhere and in more detail for other species.

The mother does not wander much after beginning to reproduce, but stays in one spot, with the younger of her progeny clustered around her.

The winged females, which may occur in any of the seventeen or more generations, are the chief means of spreading the species. They are feeble of flight, but are often assisted by the wind to reach distant places.

Fertilization is evidently essential to the production of an egg that will hatch, tho eggs are laid whether fertilization has occurred or not. The deposition of an egg requires about seven minutes, as noted by E. O. G. Kelly, who observed also that the female used her hind legs to assist the egg out. A fluid that accompanies the egg serves to glue it to a green leaflet, on either side of which the egg may be laid. The eggs remain over winter on the dead leaves or stems on the ground.

In November there are still many mature females in the field, and they feed on mild days, crawling under shelter when the weather turns cold. If clover sod is brought indoors during the winter, the females appear with the new growth and the plants soon become overrun with aphids. Out-of-doors, most of the hibernating females meet their death sooner or later during the winter, in this region, notwithstanding the fact, reported by W. G. Johnson, that the species can survive severe freezing.

Natural Enemies.—The most important enemy of this louse is a common fungus, *Empusa aphidis.* It is wide-spread in the United States and Canada, and affects a great variety of aphids, its abundance, when it occurs, being proportional to that of its host. It does not appear in dry weather but is common after a rain or two at any time during the growing season, and is most abundant under the combined influences of moisture and warmth. Then it sweeps off myriads of aphids. Those killed by the epidemic remain clinging to the plant in a more or less lifelike attitude, but turn yellow and then light brown, become swollen, and eventually coated with the fungus (Pl. II., Fig. 3). The

appearance of the insect is at first similar to that caused by the presence of a larval *Aphidius* in the body of the aphid. The parasite, however, at length spins a silken cocoon under the aphid, and whenever present can easily be found by dissection.

The life history of this fungus is like that of *E. sphærosperma,* as given in some detail in the account of the clover leaf-weevil, and is discussed at length by Thaxter in the Memoirs of the Boston Society of Natural History, Vol. IV., 1888, pp. 175–177.

Macrosiphum pisi is affected, directly or indirectly, by a large number of other insects, of which other writers have recorded twenty. These and thirteen additional species are listed below.

Gryllidæ
- Œcanthus confluens H. & H. MS.

Pentatomidæ
- Podisus maculiventris Say (= spinosus Dall.)
- Euschistus variolarius P. B.

Acanthiidæ
- Triphleps insidiosus Say

Chrysopidæ
- Chrysopa oculata Say
- Chrysopa rufilabris Burm.
- Chrysopa plorabunda Fitch

Syrphidæ
- Ocyptamus (Baccha) fuscipennis Say
- Platychirus quadratus Say
- Syrphus americanus Wied.
- Syrphus ribesii L.
- Allograpta obliqua Say
- Mesogramma marginatum Say
- Mesogramma politum Say
- Sphærophoria cylindrica Say

Ichneumonidæ
- Bassus lætotorius Fab.

Coccinellidæ
- Megilla maculata DeG.
- Hippodamia glacialis Fab.
- Hippodamia convergens Guér.
- Hippodamia tredecimpunctata L.
- Hippodamia parenthesis Say
- Coccinella novemnotata Hbst.
- Coccinella sanguinea L.
- Adalia bipunctata L.
- Chilocorus bivulnerus Muls.

Lampyridæ
- Podabrus rugulosus Lec.

Cecidomyiidæ
- Diplosis sp.

Braconidæ
- Perilitus americanus Riley
- Trioxys (Praon) cerasaphis Fitch
- Aphidius fletcheri Ashm. MS
- Aphidius washingtonensis Ashm. MS.

Chalcididæ
- Isocratus vulgaris Walk.
- Pachyneuron syrphi Ashm.

Acarina, Rhyncholophidæ
- Rhyncholophus parvus Banks

Most of these species I have studied in Illinois in their relation to *M. pisi.* Below is a summary of all that we know on the subject up to the present date. All these insects, concerned in one way or another with the clover-louse, are either predaceous or parasitic.

Coccinellidæ.—The omnipresent ladybird beetles and their larvæ are in this region the most efficient of the insect enemies of the clover-louse. The larvæ in particular destroy the louse in immense numbers. They are by no means limited to this aphid, but when it predominates, the number of *Coccinellidæ* present is a good measure of the abundance of the louse.

The hemispherical, brightly colored ladybird beetles (Fig. 6) are familiar, tho their larvæ are not so generally recognized. The entomologist knows them as active little alligator-like creatures, with a long warty or spiny abdomen. Some of them are blackish, but most of the common kinds are spotted with conspicuous colors. The pupa is attached by the tail to a silken support spun by the larva on a green leaf or other object. Its period is four to eight days, usually five or six in July, in the case of several of our common species. The yellow elliptical eggs, laid in small clusters, are conspicuous on green leaves and elsewhere.

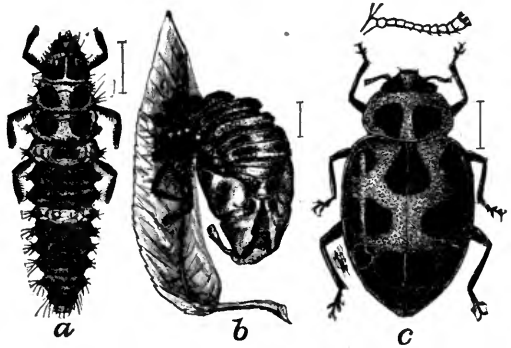

FIG. 6.—Ladybird, *Megilla maculata: a,* larva; *b,* empty pupal skin; *c,* beetle. (Chittenden, Circ. 43, Bur. Ent., U. S. Dept. of Agriculture.)

Coccinellidæ in general hibernate as beetles, and all the species mentioned here do so. They are among the first insects to appear in the warm days of late March and early April. Comparatively few at the opening of the season, they multiply rapidly, tho in this respect they lag somewhat behind the plant-lice on which they feed, if the latter are at all numerous. *Coccinellidæ* feed also on scale insects, pollen grains, spores, etc., as Forbes found (Bull. No. 6, Ill. State Lab. Nat. Hist., 1883, pp. 33–64), but feed chiefly on plant-lice, and thus are beneficial.

Adalia bipunctata and *Hippodamia glacialis* were not often met with in the clover field, and *Coccinella sanguinea* was not numerous. *Chilocorus bivulnerus,* well known as a destroyer of scale insects, was rather common at times as an enemy of the clover-louse. The other species listed above were always common. *C. 9-notata* we noted as emerging as a beetle June 29, July 16 and 18; *C. sanguinea,* June 23; *H. 13-punctata,* July 15, 16, and 18; *M. maculata,* June 20, 21, 22, and 24; *H. parenthesis* issued July 1, 2, and 5, from pupæ found June 27; and eggs of this species, found June 14, hatched June 20, one of the larvæ pupating July 11 and giving the beetle July 15.

All the species listed were actually seen feeding upon *M. pisi,* either in the field or in the insectary. In the latter place, the diet of three *Megilla maculata* beetles included also (to their discredit) one coccinellid pupa, one adult *C. sanguinea* and two beetles of their own kind, besides some of their own eggs and (to their credit) eggs of the Colorado potato-beetle that were offered to them.

Perilitus americanus, a braconid parasite of the beetle of *Megilla maculata* and now and then of *C. 9-notata,* we reared several times from the former host. Parasitized beetles taken on clover leaves June 17, gave the winged braconid June 21 and 22; others, of June 23, gave

the adults June 30. My own experience with the parasite leads me to take no exception to the accounts already published by Riley (*Insect Life,* Vol. I., pp. 101–104, 338, 339) and by Weed and Hart (*Psyche,* Vol. V., pp. 188–190). Briefly, it may be said the beetle is found standing on a leaf and looking quite natural; indeed, it can still move some part of itself in most instances, tho it can not move away from the spot, for it is held by its feet to a brown mass of silk—a cocoon, from which the parasite will emerge in its winged form. The beetle may remain alive in this condition for two weeks and doubtless a little longer, but when disentangled from its foothold it is unable to move its legs in coordination—is unable to walk.

The larva that made the cocoon has issued from the beetle and could previously have been found inside the host, but some mystery exists as to where the larva makes its exit, for the shell of the beetle appears to be unbroken.

This *Perilitus,* then, is a check upon the beneficial ladybird beetle, but is of no practical importance on account of its infrequency.

On many occasions I have seen adults of *Podisus maculiventris (spinosus)* and *Euschistus variolarius* sucking the pupæ of various of the coccinellids that prey upon the clover-louse. The eggs of both these pentatomids are heavily parasitized by a proctotrypid.

Syrphidæ.—Among the commonest insects of the clover field are several species of *Syrphidæ,* or flower-flies (Fig. 7, 8), some of which are known also as "sweat bees." Many of these flies are banded with black and yellow, and have the habit of poising over this or that spot for a few moments and making short dashes from one place to another. The flies lay their eggs in or near colonies of plant-lice, upon which the larvæ are to feed. The larvæ are leechlike in form, and generally green, yellow, or mottled brownish in color. They are often seen among the aphids, which they destroy at a rapid rate. The syrphid larva seizes an aphid between its hooklike jaws, holds it aloft and sucks the blood from the body, meanwhile waving itself to and fro. When full grown, the larva shortens and its skin hardens into a brown pear-shaped or elongate puparium, from which the fly will issue.

In this region the flies are seldom noticed in the clover field before the latter part of April, but are abundant by the last of May. The larvæ grow rapidly, and there are several generations of the common species each year.

In Maryland, Johnson found the syrphid larvæ to be the most important of the insect enemies of *M. pisi,* which they nearly exterminated in some localities. One pea grower sieved out twenty-five bushels of syrphid larvæ in a few days.

Allograpta obliqua Say, he found to be by far the most common and most important species, forming the greater bulk of the twenty-five bushels mentioned. He refers to the larvæ as being pea-green, slightly streaked with white, and one quarter to one third of an inch in length when full grown. The puparium is usually found on a leaf or stem, rarely on the ground.

Sanderson, in Delaware, found almost all the puparia of *Allograpta obliqua* to be parasitized by *Bassus lætotorius* Fab., and from several puparia which seemed to have been parasitized by the *Bassus* were bred the chalcid *Pachyneuron syrphi* Ashm. *B. lætotorius* is also parasitized by *Isocratus vulgaris* Walk., according to Fletcher.

A. obliqua is a common species in Illinois, where the larva feeds on *M. pisi* as well as on other aphids.

Syrphus americanus Wied., one of the largest species of the family, has conspicuous bands of black or yellow, and buzzes like a bee when on the wing. The larva is greenish or mottled brownish, attains a length of half an inch or more, and pupates on the plant or a little below the surface of the ground, as Johnson noted. The species deposits a single small oval white egg in a colony of plant-lice, and one of the larvæ has been observed to eat twenty-five plant-lice in as many minutes, according to Sanderson. In Delaware, he found it to be extremely abundant as an enemy of *M. pisi*; in Illinois, it feeds on the same species and is frequent but not conspicuously numerous.

Syrphus ribesii L. is reported from Canada, by Fletcher, as an abundant foe of the aphid, and as being attacked by *Bassus lætotorius,* which, in turn, falls prey to the chalcid *Isocratus vulgaris. S. ribesii* occurs with us, but I have never happened to take it in the clover field.

Sphærophoria cylindrica, a small syrphid named by others as affecting *M. pisi,* is rather common here in aphid-infested clover fields.

Mesogramma politum (Fig. 7, 8) is frequent in our clover fields, the green larva feeding on the clover-louse. A full-grown larva found on the ground March 27, made its puparium the same day, and the fly issued indoors April 8.

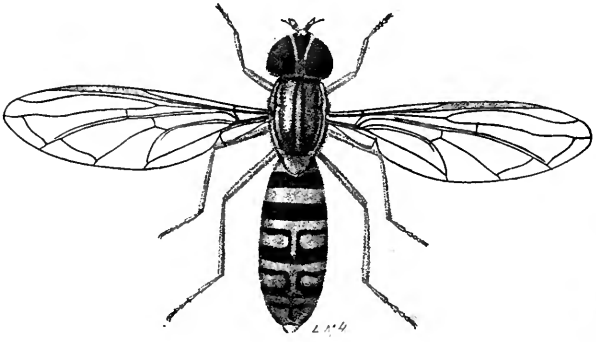

FIG. 7.

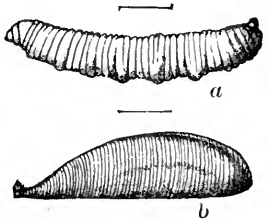

FIG. 8.

Syrphus-fly, *Mesogramma politum*: Fig. 7, adult; Fig. 8 (*a*), larva, (*b*) puparium. (Riley and Howard, U. S. Dept. of Agriculture.)

Mesogramma marginatum has similar habits and is common. A puparium found on a clover leaf June 21 yielded the adult June 22.

Platychirus quadratus, a small and frequent species, and the less common *Ocyptamus fuscipennis,* I have taken in sweepings, along with the abundant *M. pisi.* It is probable that their larvæ feed on the clover-louse.

Various syrphid larvæ that destroy *M. pisi* are themselves attacked by *Podisus maculiventris (spinosus)* and *Euschistus variolarius;* and the eggs of these pentatomids are parasitized by a proctotrypid, *Telenomus podisi* Ashm. (determined by A. A. Girault).

Chrysopidæ.—A few species of *Chrysopa* (Fig. 9) are common in the clover field. The adults, known as lace-wing flies, are green or less often yellow, with golden eyes and four similar gauzy wings, finely netted with veins. A few species have a characteristic odor—*C. oculata,* for example. By day the flight is rather sluggish, but toward evening the lacewings become more alert; they often fly to a light at night. Most of the species hibernate as pupæ, so far as is known, but *plorabunda* winters as an adult. We have often found it hibernating under dead leaves; then the insect is brown in color. Our species lay

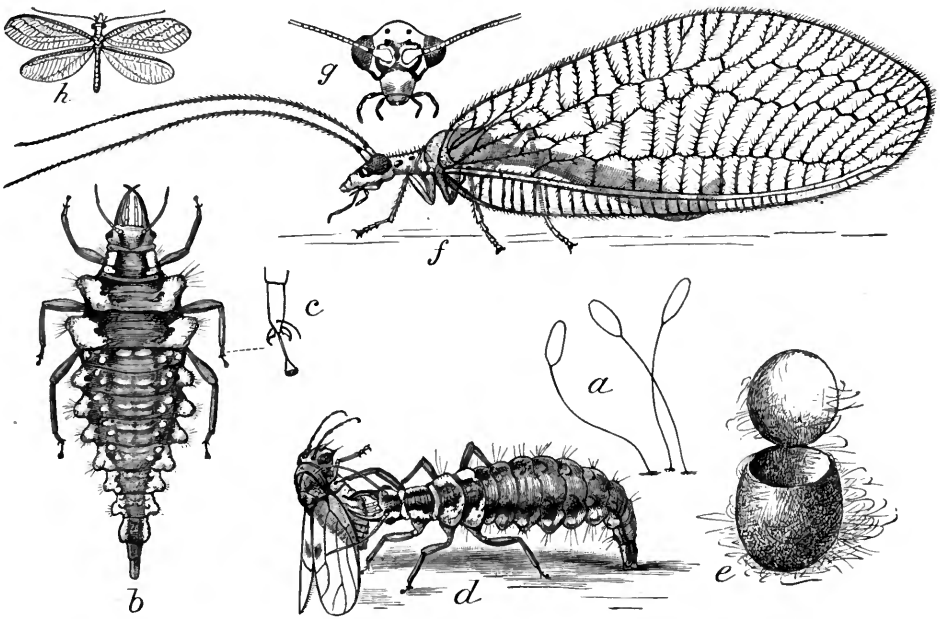

FIG. 9.—Lace-wing Fly, *Chrysopa oculata: a,* eggs; *b,* larva; *c,* foot of same; *d,* larva devouring pear-tree Psylla; *e,* cocoon; *f.* adult; *g,* head of same; *h,* adult, natural size. (Chittenden, Circ. 43, Bur. Ent., U. S. Dept. of Agriculture.)

their eggs each at the tip of a long stiff thread and always in the vicinity of plant-lice, which are the chief food of the larvæ. In clover fields the eggs are common on leaves or stems, and the larvæ eat ravenously *M. pisi* and other aphids, and eat one another now and then,—particularly when a lot of them issue at the same time from one cluster of eggs. The prey is seized between the points of the long, tapering mandibles of the aphis-lion and the blood is sucked back thru a channel made by a groove along the inner face of the mandible, against which the maxilla fits, to form a closed channel. A newly born larva,

unless cannibalistic, selects for its first meal a small tender aphid; under the microscope, one can see the watery juices of the victim bubbling along the transparent jaws of the captor. These larvæ are active creatures, gray, yellowish, or brownish in color, tho colorless at birth. They grow rapidly, and in one to three weeks spin a silken cocoon by means of glands opening into the rectum. The cocoon, spherical or oval, shows, after the emergence of the adult, a circular lid.

The *Chrysopa* larvæ are undoubtedly important checks on the clover-louse. In red clover I have found three species, namely, *oculata, plorabunda,* and *rufilabris*. The last was not common; but the first two were numerous, and their larvæ were frequently seen feeding on *M. pisi,* upon which we reared them in the insectary.

A larva of *oculata,* taken July 7, spun July 10 or 11 and gave the adult July 27.

A larva of *plorabunda* gave precisely the same record. A second larva of this species, taken in a colony of *M. pisi,* spun July 10, in a bent leaflet, the adult issuing July 20.

C. rufilabris emerged July 24 from a cocoon found on a clover leaf July 20.

We have reared no parasites of *Chrysopa,* but others have obtained from cocoons of this genus many species of chalcids and a few ichneumonids, and from the eggs one proctotrypid.

The most important of the predaceous foes of the clover-louse belong to the three families just discussed. There remain to be treated, several predaceous species of more or less importance.

While the seed-midge works havoc in the clover heads, another member of the same family is busily engaged in reducing the numbers of the clover-louse, at least in Canada, for all that we know about this helpful but undetermined species of *Diplosis* is what Dr. Fletcher learned at Ottawa, where in 1900 it was by far the most inveterate enemy of *M. pisi* on pea-vines. These minute orange maggots would transfix an aphid, hold it up, and suck out the blood, in much the same way as the syrphid larvæ. Their growth was so rapid as to result in several generations during the season. Winter was passed in a minute cocoon, spun on the stem of the plant or on the ground among grains of sand.

At Highland, Ill., August 11, I found on the red clover large numbers of both sexes of a tree-cricket (*Œcanthus*), and watched them devour the clover-aphid at a great rate. Afterward we kept these tree-crickets alive in the insectary for a long time and found it no small trouble to keep them supplied with enough plant-lice. Big, as compared with their victims, they soon cleaned a plant of aphids. One male ate nineteen full-sized aphids at one meal, lasting fifty-five minutes, an aphid being finished in ten to ninety-five seconds,—about one louse per minute on an average. In this instance, it should be said, Mr. Kelly facilitated matters by handing the cricket a new aphid as soon as the old one was finished. The same cricket, on the following day, being induced to repeat his performance, beat his previous record

by devouring eleven aphids in eighteen minutes, but fell short of his record for fifty-five minutes.

As an inveterate enemy of *M. pisi,* this *Œcanthus* is undoubtedly far ahead of Dr. Fletcher's *Diplosis* in capacity, but unfortunately does not appear to be wide-spread, tho it is probably common in southern Illinois.

This species of *Œcanthus* agreed with none of the published descriptions, but I found that Mr. C. A. Hart and Mr. J. D. Hood had seen the same species and given it the manuscript name of *confluens.*

Triphleps insidiosus, an active little flower-bug (Fig. 10) frequently impales *M. pisi* and sucks its blood. In our breeding experiments with the clover-louse this little intruder had to be excluded, as it played mischief with the birth-records.

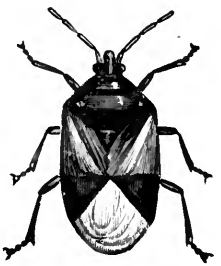

FIG. 10.—*Triphleps insidiosus.* Enlarged. (After Riley.)

Podisus (Fig. 11) and *Euschistus* (Fig. 12) as nymphs or adults destroy a clover-louse once in a while, as I noticed.

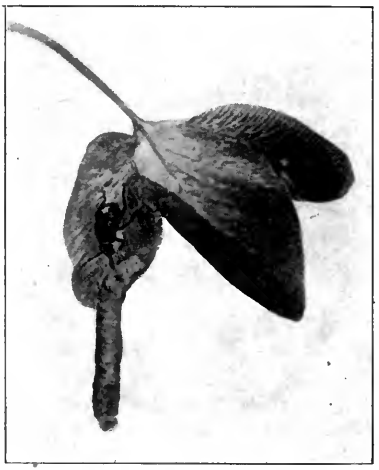

FIG. 11. — *Podisus maculiventris,* nymph, sucking the blood from a caterpillar. Natural size.

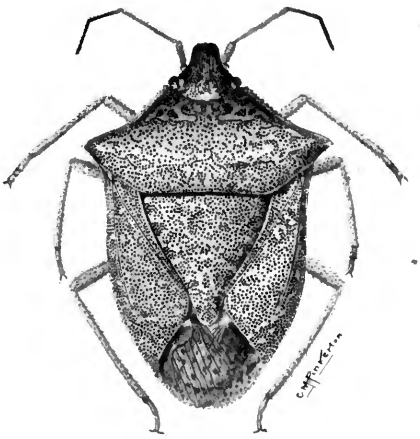

FIG. 12.—*Euschistus variolarius.* Four times natural size.

The soldier-beetle (*Podabrus rugulosus*) was found feeding on *M. pisi* in Maryland, by Johnson.

A small red mite (*Rhyncholophus parvus*) was noted by Sanderson as feeding on *M. pisi* in Delaware.

Let us now turn to the parasites of *Macrosiphum pisi.*

Aphidius.—Often there is found on a clover leaf a dead aphid, light brown in color, with the body distended, attached to the leaf in a somewhat lifelike position by means of a little silken mat, which

spreads out under the aphid and raises it above the surface of the leaf. (Pl. II., Fig. 4.) This cocoon was made by a maggotlike larva that had been feeding inside the body of the aphid. The winged braconid emerges by cutting nearly a circle thru the skin of the host, usually thru the abdomen, and leaves a circular opening with usually a corresponding lid. The mother *Aphidius* inserts a single egg into the body of an aphid.

Two species of *Aphidius* are named in the literature as destroying *M. pisi: A. fletcheri* Ashm. MS., reported by Fletcher as having done good service in Ottawa, Can., and bred from *M. pisi* in Delaware by Sanderson; and *A. washingtonensis* Ashm., also bred by Sanderson under the same circumstances. In Delaware, at least 5 percent of the lice were killed by these parasites.

In Urbana, *Aphidius* is abundant every season on the clover-louse. We have had the adults emerge June 21, 26; July 1, 3, 4, 6, 8, 12, 17; August 18, 24; and October 18, 19, —mostly early in July, however.

An *Aphidius* larva that I found July 11 spun its oval silken carpet under the aphid on the same day; July 12 the aphid had been raised above the leaf and the cocoon was complete; July 18 the adult was found, it having issued during the preceding twenty-four hours. Another black larva spun June 18 and the imago emerged June 26. From a cocoon made October 12 the adult issued October 19.

October 10 a female *Aphidius* was put into a cage containing *M. pisi,* the individuals of which had been reared under glass in a way to insure their freedom from parasites. No oviposition was witnessed (the mother dying October 21), but November 16 three of the aphids showed the cocoons of *Aphidius,* the aphids having turned brown on the day before. These aphids were kept over winter in glass vials, and June 10 a winged *Aphidius* was found to have emerged. It was dead then, but certainly did not issue before March 17, when the vials were thoroly examined.

Another braconid, *Trioxys (Praon) cerasaphis,* was bred in large numbers by Fletcher from material collected at Ottawa, Canada, the material referred to being by implication *M. pisi.*

From what has been given it can be seen that a good many different insects have to do with *Macrosiphum pisi* in one way or another, and that the interrelations of some of them are involved. Thus, *Megilla maculata,* which eats *M. pisi,* is parasitized by *Perilitus americanus,* and preyed upon by *Euschistus variolarius*—the eggs of which are food for one of the proctotrypids. *Syrphidæ* destroy *M. pisi* and are themselves food for the same *Euschistus*; furthermore, they are parasitized by *Bassus lætotorius,* which, in turn, is parasitized by *Pachyneuron syrphi* and *Isocratus vulgaris.*

Among the natural enemies of this aphid is to be counted the English sparrow, according to a correspondent of Dr. J. B. Smith, who wrote, "It was wonderful to watch them, how soon they cleared up a pea-vine. After the sparrows commenced to work, they soon cleared up every louse."

Control.—The treatment of the pest is different according to whether the insect feeds on peas or on clover.

Growers in the eastern United States and in Canada have found that early peas are practically exempt from injury, and therefore plant the early-maturing varieties when injury is probable.

On peas grown for commercial purposes, spraying is too expensive, besides being in other respects impracticable, according to Johnson's elaborate experiments in Maryland. Sanderson found, in Delaware, some little advantage in spraying while the lice are still confined to the terminals and the vines are as yet upright.

A crop can be saved by the timely and thoro use of the "brush and cultivator" method devised by Johnson. This method requires that the peas be planted in rows 24 or 30 inches apart, instead of being sown broadcast. The lice are brushed off the vines with switches of pine branches or something similar, and are then buried under ground by means of a cultivator drawn by a single horse. Cultivation should not be repeated for three days, in order to insure the death of the buried lice. On a hot day, Johnson found that lice left on the surface of the ground died in a few minutes when the temperature of the air was 94°–96° F., and that of the ground 115°–119° F. In one instance, 600 acres of peas were saved in this way; and tho forty men were necessary for two weeks to brush and cultivate the peas, the crop netted the owner 25,000 to 30,000 cases of peas of two dozen cans each.

Instead of a cultivator a large shallow pan can be used, and the lice brushed into this as it is dragged between the rows by hand. In such a contrivance, containing a little water and kerosene, Johnson collected a bushel of lice to each row of 125 rods. The pan, made of galvanized iron, may be five or six inches deep, and as wide as the distance between the rows. Sanderson recommends this method as being perhaps the best one. It can be used when the soil is too damp for the cultivator.

Sanderson states that high fertilization (as with crimson clover and lime), with frequent cultivation for several years, often enables a crop of peas to mature in spite of the louse.

As the louse winters in the clover field and spreads from clover to peas, these should be planted as far from clover as possible. If the lice are abundant on clover in spring it may be advisable to plow the clover under, and roll the ground, in order to save the peas (Sanderson).

In gardens the louse can be controlled on green peas and flowering sweet peas by spraying, as with whale-oil soap (1 pound to 5 gallons of water) or kerosene-soap emulsion, diluted with 12 parts of water. Fletcher reports success with a spray of whale-oil soap and tobacco decoction. He put 10 pounds of tobacco leaves into half a barrel of water, strained off the liquid after a few hours, added 2 pounds of whale-oil soap, and, when this was dissolved, added enough water to make 40 gallons. Two days after the application of this spray to both surfaces of the leaves most of the lice were dead, and

such parts of the rows as had received two applications were cleared of the insects.

On red clover I have seen this aphid multiply in spring until its numbers threatened the life of the plant, and then disappear, practically, thru natural agencies; this for five successive seasons. A heavy rain did the work assisted by the fungus *Empusa aphidis* and, secondarily, by the numerous and important—tho somewhat lagging—predaceous and parasitic insect foes of the aphid. Were it not for these influences the louse would become a pest of the first magnitude in spite of the vigor of the clover plant. Occasionally and locally it does become such a pest, as already related.

Unfortunately, it can not be predicted whether the clover will be killed or not, and if one is unwilling to take the chances, the safest thing to do is to cut the clover just as soon as possible. Cutting and drying the clover will kill most of the lice at any time during the season.

The hordes of lice are for the most part the progeny of the fewer lice of May, in the same field. So it follows that spring pasturing or clipping back the clover would check the multiplication of the louse.

The lice of April and May are the progeny of a comparatively few wintered females that entered the field the preceding year, and also of a few eggs laid the previous autumn in the first-year clover. Therefore it is advisable to cut or pasture the clover in the latter part of its first season—and this will not hurt the plant if done intelligently.

Macrosiphum pisi Kalt.

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1902. Sanderson, E. D.—Thirteenth Rep. Del. Agr. Exper. Sta., 1901, pp. 168–172.

CLOVER LEAF-WEEVIL

Phytonomus punctatus Fab.

Tho this insect must be counted among the most important clover pests, it has not as yet established itself as an annual menace to the hay crop. Indeed, it is ordinarily held in check by a great variety of adverse influences, and seldom gets control of the plant—reminding one, in this respect, of the army-worm.

In early spring the larvæ make small round holes in the leaves of second-year clover, as soon as the leaves have begun to grow; later, they eat inward from the margin, the injury increasing in April and May. Thruout the summer the beetles gnaw the clover leaves in a ragged fashion and may even eat the plant down to the roots.

The larvæ and beetles are not seen in the daytime, unless one hunts for them; they are nocturnal in their activity. The larvæ, curled up under rubbish on the ground, are green with a white stripe along the middle of the back; they have no legs and are sluglike when inactive. The adults—tough, oval, brown beetles—are also found on the ground during the day, motionless, with the legs and antennæ drawn up against the body, or else moving away sluggishly when exposed to the light.

Distribution.—Tho this species has been familiar to European entomologists for more than a century, occurring as it does thruout Europe and in western Siberia, it was not recognized in this country until 1881, when its ruinous work was reported from Yates county, New York. At present the species is known to occur in Vermont, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, District of Columbia, West Virginia, North Carolina, Ohio, Indiana, Illinois, Michigan, and Wisconsin, and also in Ontario, Canada. From the data collected by F. M. Webster, the insect appears to have spread from New York into Ohio, then westward; also from New York into Canada. At Ridgeway, Ont., Mr. A. H. Kilman found that the beetles were being brought by the east wind, August 10, 1884. On the same day, at Buffalo, N. Y., ten miles due east of Ridgeway and across the lake, the beetles swarmed on the pavements and could be collected by the quart along the lake shore. Reinecke noted their abundance in Buffalo following a heavy east wind.

Food Plants and Injuries.—The food plants in Europe are given as *Trifolium* (clover) and *Medicago sativa* (lucerne, alfalfa). In the United States the insect eats all kinds of clovers, and alfalfa as well. The other food plants that have been named, are beans and timothy for the larva, and burdock and the flowers of goldenrod for the beetle.

Webster observed a preference for white clover over red. In central Illinois red clover is most heavily infested, alfalfa coming second, and white clover third. Mammoth clover and alsike are freely eaten if they happen to be available.

European accounts refer but scantily to this species as a pest, aside from references to its devastations in Italy in the years 1867–70;

and in this country the insect, tho often abundant, seldom accomplishes the injury anticipated because the larvæ are usually killed in spring by a fungous disease. When this species cooperates with the root-borer, in a time of drought, injury of the worst kind may ensue.

The larvæ eat the leaves, and the beetles eat the leaves and stems also, as described later.

Description.—The egg is easily visible as a yellow object (chrome-yellow at first), elongate oval, 1.1 mm. long and 0.6 mm. broad. It darkens in from two to six days after being laid, and the surface is then rough, and sculptured with hexagonal depressions.

In the clover field the larvæ of this species (Fig. 13) can not easily be mistaken for anything else. They are green usually, and lie on the ground curled head to tail. Close examination shows that they are footless and have a brown head, while along the middle of the back is a white or pale yellow stripe edged with rose-red or black-

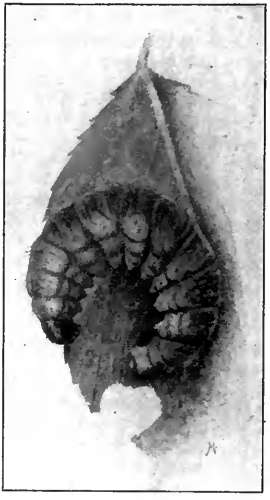

FIG. 13.— Clover leaf-weevil, *Phytonomus punctatus*, larva. Greatly enlarged.

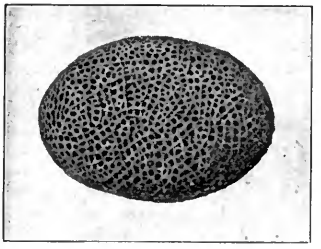

FIG. 14.— Clover leaf-weevil, *Phytonomus punctatus*, cocoon. Greatly enlarged.

ish red. The youngest larvæ, to be sure, differ from this description, for when only 1.5 mm. or 2 mm. long, they are white or pale yellow, with a jet-black head and only a suggestion of the characteristic median dorsal stripe; they are curled up on the ground and sluggish, however, just like the older larvæ.

Riley (1882, p. 178) gave a detailed description of the larva in its four stages. The body tapers gradually toward each end. The color, white at hatching, becomes green as soon as a meal has been taken. Some larvæ, however, are distinctly yellow instead of green, and a few are bluish green. The head, black in the first stage, becomes afterward brown or yellowish brown. The second stage (after the first moult) is marked by the appearance of the broad white dorsal line, bordered on each side by a blackish streak, and the length of the larva is 4 mm. After the second moult this line is more conspicuous and the length of the larva is 5 to 7 mm. With the third and final moult, the larvæ become decidedly green, tho the posterior part of the

body remains yellowish; the dorsal line becomes tinged with rose color and edged with blackish rose; length 8 to 14 mm. The cocoon is oval (Fig. 14), 9–10 mm. long and 6.5–7 mm. broad, and is composed of a coarse network of brownish threads.

The newly formed pupa (Fig. 15) has a yellowish green head, small black eyes, and yellow antennæ, legs, and wing-pads. The abdomen is dark green with a pale dorsal line, and bears numerous hairs at its extremity and a transverse series of dorsal setæ on each of its segments.

The beetle (Fig. 16) is a stout, oval, brown, finely punctured curculio. The female is about 8 mm. in length and 4.5 mm. in greatest width, some specimens being as long as 8.5 mm. The prevailing color

FIG. 15.

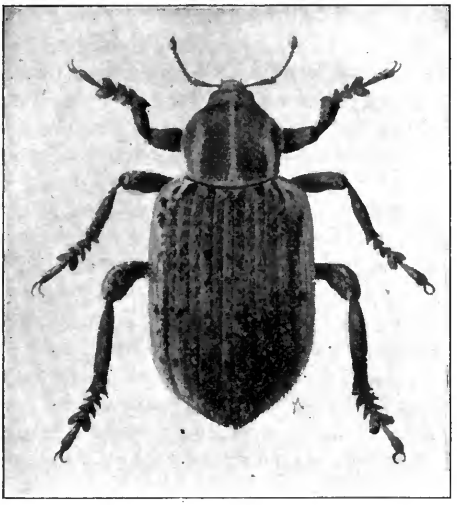

FIG. 16.

Clover Leaf-weevil, *Phytonomus punctatus*: Fig. 15, pupa; Fig. 16, beetle. Greatly enlarged.

above is brown, but the sides of the prothorax and elytra are washed with pale yellowish brown, which on the elytra covers the outer five interspaces. Occasionally there is a pale sutural line. The elytra are marked above with small black spots, due to scales which occur at regular intervals on the interspaces. The prothorax is much narrower than the abdomen, subquadrate, and one fifth broader than long, with the sides rounding anteriorly and converging slightly posteriorly. The pronotum has three pale longitudinal lines, one in the middle and one on each side. The eyes are transverse. The beak is half as long again as the head, stout and curved, with deep antennal grooves. The scales and the short sparse setæ of the body are either brown or yellow.

The male, 7 mm. in maximum length, differs from the female in being smaller and narrower, with the sides of the elytra less rounded;

it is also darker in color than the female, with a narrower pale area on each elytron, the two outermost interspaces being dark instead of pale. The pygidium (which is not exposed) is, as usual in the family *Curculionidæ,* divided by a transverse suture so as to form an additional, or anal, segment; thus the male has eight "dorsal segments" and the female seven.

P. punctatus is distinguishable at once from our other species of *Phytonomus* by its coloration, large size, and stout beak. As to smaller differences, *punctatus* is characterized by having mandibles that are not emarginate at the tip, while the first and second segments of the funicle are equal; in the other species of the genus the first segment is stouter and often longer than the second, and the beak is longer and more slender than in *punctatus.* In the clover field, this beetle will be recognized without difficulty.

Life History.—In central Illinois we have only one annual generation of this insect, as seems to be the rule elsewhere. All thru the winter small larvæ can be found in the clover field under rubbish on the ground or between the bases of the clover stems. In early spring the few warm days that start the clover on its new growth revive the larvæ also, and they begin to mar the fresh clover leaves with little round holes eaten out of the blades of the leaflets. In the early season of 1907 the first new leaves of red clover began to show March 19, and were already riddled by these larvæ March 23, at which date the larvæ were common on the ground near the affected plants. In early spring the larvæ are of many sizes, with an average of 5 mm. in length, tho many are only 2 or 2.5 mm. long, and a few are as long as 7 mm. I have rarely found the beetles in early spring, and such as were found were either dead or in the last stages of decrepitude, and evidently incapable of doing anything toward the propagation of their kind.

I have not found more than four larval stages—the number given by Riley. The first stage lasts about nine days, in the insectary; thus larvæ born November 16 moulted for the first time November 25. Some of the larvæ, born in late autumn, do not moult until the following March or April. For example, one larva was in its first stage April 1; it moulted April 8, April 17, and May 4, and spun May 20. The intervals between moults are, however, very variable, especially when the weather is unsettled, and the growth of the larvæ is consequently intermittent.

The pupal period indoors we have found to be 10 to 20 days, as in four instances following:

(1) Spinning occurred April 22; pupation, April 24; emergence, May 11.
(2) Spinning occurred April 22; pupation, April 24; emergence, May 14.
(3) Spinning occurred April 24; pupation, April 30; emergence, May 20.
(4) Spinning occurred May 20; pupation, May 27; emergence, June 6.

Larvæ of various sizes are common in April and May, but nearly all attain their growth before June 20. Rarely, beetles of the new generation appear as early as May 9; on that date we once found two

freshly emerged beetles in the field. The latest date for their emergence may be given as July 15. Many beetles issue daily from June 5 to June 30, and most of the beetles issue during the last week of June.

Early as the beetles appear, they do not begin to mate until the last week of August, and nearly all the eggs are laid in September and October.

We have insectary records of oviposition for almost every day between September 17 and October 26, and almost daily records of hatching from October 9 to November 27. The egg period in autumn is from 23 to 45 days, averaging 29 days; the length of the period depends upon temperature chiefly; some of the latest eggs, indeed, do not hatch until the following spring. Out-of-doors we have found eggs as late as November 14, and young larvæ as early as October 10. After that date they soon become common, and can be found at any time during the winter between the bases of the clover stems, as deep as possible, or else on the ground under more or less protection. Many of them succumb to the cold, however. These winter larvæ also are of various sizes. Sixty-five larvæ measured November 26 ranged in length from 2.5 mm. to 7.5 mm., with an average of 3.17 mm.

Late in October a few living beetles—more than three months old—occur in the clover field and go into hibernation. Early in the following spring their dead bodies may be found. Farther south, it is possible that enough beetles survive the winter to influence the course of the life history.

The preceding general account of the life history is based upon such a large body of observations that it represents the actual conditions with considerable accuracy, for central Illinois. A few precise notes are added on account of their significance.

Many eggs laid between October 16 and 25, 1905, were apparently sound January 21, 1906, and had not hatched February 23; but March 21, young larvæ from them were found, still alive, and 2 mm. in length. Again, eggs laid October 26, 1904, did not hatch until April 13, 1905.

I have several times followed the consecutive life history for a year or more. The longest account, covering a period of eighteen months, begins with a female beetle taken September 23, 1904. She laid eggs as follows:

Sept. 26, one mass of eggs.

Oct. 1, three egg-masses; hatched Nov. 3 and 4; larvæ alive Nov. 21, but died during winter.

Oct. 9, several eggs laid; they hatched November 19; the larvæ died in winter.

Oct. 26, several eggs laid; unhatched April 12, 1905; hatched April 13.

Nov. 1, three eggs; hatched Nov. 27, in warm room. The mother was alive Nov. 21, but died during the winter.

The larvæ that were born April 13, 1905, were reared; they buried

themselves in the ground May 23 and 24 and gave beetles June 13. Four of these beetles were kept alive until August 28, and August 29 one male and one female remained. The female laid eggs Oct. 16, 17, 21, 24, and 25. These eggs had not hatched February 23, 1906, but had just hatched March 21; by March 29 the larvæ had died, however, from a scarcely excusable neglect to supply them with food. The parent beetles had died the year before, about November 11.

This account of the life history is in some respects at variance with that of Riley (1882, pp. 175, 176). In central Illinois the egg period in autumn is from 23 to 45 days in the breeding-cage. Furthermore, none of the larvæ born in autumn give beetles in that season; the beetles do not emerge until the following June or thereabouts, and some of these are the beetles that will enter upon hibernation. In my experience, no eggs are laid in spring. In a warmer latitude than this there might very well be a second generation of beetles, to hibernate and to lay eggs the following spring. Indeed, in this latitude, the little autumn larvæ, if taken indoors and fed, will produce beetles in midwinter.

Here, then, the clover leaf-weevil winters chiefly as a small larva; occasionally in the egg; never as a pupa, in my experience; and rarely as a beetle. No eggs are laid in spring, however, and there is clearly but one generation a year, tho this generation is straggling instead of compact.

Habits.—The larvæ that have hibernated are ready to eat the red clover as soon as it starts on its second year's growth. At any time during the winter one can get plenty of these larvæ by digging up clover sod and starting the growth of the clover indoors.

In midwinter, on a mild day (Jan. 6, 1903), the larvæ were feeding in abundance on red clover plants in Urbana, Ill. (R. D. Glasgow)—and in broad daylight. This is unusual, for at other times of the year they feed only at night or else at dusk or in daytime when the sky is sufficiently cloudy. Ordinarily, when the sun is shining they are found curled up in shaded situations, usually on the ground, but occasionally among the stems of their food plant. When feeding at night the larger larvæ drop to the ground when approached, but the smaller ones remain clinging to the leaflets, just as Riley observed. The larva frequently curls itself around the edge of a leaflet and bites out a small round piece from the blade; or it may secure a hold by gripping a hair of the leaf between two of its body segments. Only the youngest larvæ make the little round holes in the leaflets; the older larvæ eat gaps in the edges.

The feeding of the larvæ in spring is more or less intermittent, being suspended at every cold spell. In 1907, when the entire month of April was cold in central Illinois and frequent freezes blackened more than one third of the red clover leaves, the larvæ of the leaf-weevil, like their food plant, made no growth during the month of April, but became dormant again until May, tho they had been active during the warm weather of late March. Retarded in their develop-

ment by one month, they made up in May for what they had lost, and the majority of the beetles appeared at the usual time in June.

The locomotion of the larva is peculiar. The larva secures a hold on a hair by means of its mouth; then brings forward the end of the abdomen to secure a new hold, and stretches forward the rest of the body. Tho the larva is termed footless, it has, nevertheless, paired ventral fleshy tubercles which, from their anatomical relations, are evidently equivalent to the legs of other larvæ; also a median ventral prothoracic tubercle. These muscular tubercles assist in locomotion, especially on smooth surfaces. As the larva walks on the under side of a sheet of glass, slightly moistened, a suckerlike action of these tubercles is evident.

The color of the larva is white at birth, but a green tinge appears as soon as the larva has taken its first meal of green plant tissue. Some larvæ are yellow instead of green; diseased larvæ are generally yellow, tho not all yellow larvæ are diseased. Now and then a larva is found having a decided blue tinge.

When full grown the larva buries itself just under the surface of the soil and makes an oval cell, against the smooth wall of which it spins the cocoon; once in a while the cocoon is constructed among the bases of green clover stems. The cocoon, oval in form, consists of a coarse network of threads with round or oval meshes; it is pale yellow at first, becoming brownish with age. The actual spinning is done with the mouth. The first threads are laid in haphazard fashion across one another; but after a coarse framework has been made, the larva lays the later threads along beside the earlier ones, forming a stout network, and gradually reducing the meshes to small rounded holes. At intervals the supply of silk fluid in the mouth gives out; then the larva reaches back to the end of the abdomen and by an assiduous process of nibbling secures a new supply of the silk fluid from the rectum, and resumes its spinning. This performance always occurs, and can be observed easily with a hand lens in the earlier stages of cocoon-spinning. Riley and J. A. Osborne were each partly correct in their accounts of the spinning (Riley, 1882, p. 175).

The beetle eats its way out of the cocoon and enters upon a long and lazy existence of feeding by night and resting by day. Not until the last of August do the beetles arouse to reproductive activity. In summer they are sluggish in the daytime, under debris on the ground, but at night they are contrastingly alert. They reduce clover leaves to rags, beginning at the margins and eating inward, usually leaving the stout bases of the veins, but sometimes devouring the entire plant down to the ground—stalks, flower heads, and all. Incidentally, they spot the plants with a brown fluid. Like the larvæ, they are quick to drop when approached.

We have many times kept these beetles alive all summer, waiting for them to lay eggs. When the time comes they lay the conspicuous yellow eggs in profusion in the breeding-cages, with or without method, as the case may be. The female may scatter her eggs about promis-

cuously or place them in small bunches on the plant or elsewhere. In other instances she bites a hole in a clover stem and inserts an egg lengthwise, pushing it far in or leaving it sticking out of the stem. Sometimes she makes a cavity without laying an egg in it. Often the female eats her eggs. In a breeding-cage that is sufficiently shaded, eggs may be laid during the day; normally they are laid at night. Mr. R. L. Webster observed oviposition in our insectary October 16, beginning at 6:30 p. m. He found a female clinging to a clover stem, with her head downward, and piercing the stem with her rostrum, thrusting it in almost to the antennæ. At times she would raise the body on the front pair of legs as if throwing her entire weight on the beak. Having made a sufficiently large hole, she reversed her position and inserted a single egg; the actual oviposition took not more than twenty seconds. Then she made another hole but did not attempt to lay an egg in it.

Out-of-doors the eggs are found inserted into clover stems, but occur also, to some extent, on the base of the plant, where the stems join; rarely they are found on the ground.

The male often accompanies the female on her round of oviposition and there are repetitions of the process of fertilization, alternating with the periods of oviposition. September 25, a pair of beetles were put on potted red clover; Sept. 27, twelve eggs were laid; Sept. 28, six; Sept. 29, several; Oct. 5, several; Oct. 8, several more; Oct. 17, copulation occurred, probably for the second time; Oct. 23, more eggs were laid; Oct. 31, the female was missing.

The largest number of eggs that we have obtained from one female is forty.

Usually the female takes three or four weeks to lay all her eggs, under insectary conditions. In the field the period of egg-laying appears to be shortened, in the last of the season, by frost.

Our observations on the habits of this species are in accord with those of Riley, except as regards some minor details of locomotion and silk-spinning.

Natural Enemies.—Riley notes the larva of a small beetle, *Collops quadrimaculatus,* as feeding upon the eggs of the clover leaf-weevil, and *Cicindela repanda* as probably preying upon the larva of the weevil. In Europe various ichneumons parasitize *Phytonomus* larvæ, but in this country no such parasites have come to light as yet.

Webster mentions the fact that the larvæ are destroyed by birds, and that barnyard fowls, especially turkeys, are very fond of them.

The worst enemy of the leaf-weevil is an epidemic disease, that under favorable conditions sweeps off the larvæ by the wholesale. This disease, due to a fungus, needs damp and not too cold weather for its development, and affects the larvæ in April or May and again in October and November, but not during winter. The contagion is rapid and thoro; no matter how abundant the larvæ are, the infection spreads until, after two to four weeks, it is almost impossible to find a

living specimen. "The sick larvæ of all ages crawl up the herbage during the night, and instead of again concealing themselves near the ground on the approach of light, as the healthy ones do, ascend as high as possible, and if on grass, coil themselves in a horizontal position about the apex of the blade, or if on other objects, take a position as nearly similar as the shape of the object permits. If disturbed before the middle of the forenoon, the majority are still able to crawl, although sluggishly; by noon most of them are quite dead, but unchanged in appearance. It will be found that they cling to the leaf with greater tenacity than during life.....Late in the afternoon, the body has changed from the normal yellowish or pea-green and smooth appearance to a velvety gray. The next morning there is only a small, blackened and shriveled mass remaining, while the surrounding foliage is powdered with a whitish, clinging dust, composed of the spores of the fungus. If some of the dead insects had been placed on a pane of glass, and a tumbler inverted over them during the night, they would have shrunken less, and been covered with a white fleecy growth, while on the glass, surrounding each body, would have been a white halo of spores two-thirds of an inch in diameter, such as everyone has observed about dead flies on the window in autumn. This is the general course of this rapid and fatal disease." (J. C. Arthur.)

This fungus, known as *Empusa (Entomophthora) sphærosperma* Fres., is found in the body of the larva as a network of colorless branching threads (mycelium) which absorb the fluids of the body; some of the branches push thru the ventral wall of the body and attach themselves to the nearest surface as holdfasts (rhizoids); other branches pierce the skin and form a gray velvety coating on the body of the larva, and the tips of some of these branches each form a spore (conidium), which is finally projected forcibly into the air, to infect any other larva that it may happen to hit. These temporary spores germinate at once, pushing out one or more threads, which enter the host and grow, forming a mycelium. There are also resting spores; these develop within the body of the host and are capable of surviving for a longer period than the temporary spores.

Other and more technical details in regard to the fungus are given by J. C. Arthur (Fourth Rep. N. Y. Agr. Exper. Sta., 1885 [1886], pp. 258-262) and by Thaxter (Mem. Boston Soc. Nat. Hist., Vol. IV., 1888, pp. 172–175).

This fungus is by no means dependent upon the clover leaf-weevil for its existence, for it has a long list of hosts, representing most of the larger orders of insects. The list includes the common cabbage-worm, mosquitoes and some other flies, ichneumons, certain leaf-hoppers, etc. Fortunately, also, the fungus is widely distributed in America as well as in Europe. In this country the ravages of the fungus on the leaf-weevil have been reported from nearly every region in which the weevil has been injurious.

Control.—The reported outbreaks of the larvæ in spring have almost always been suppressed by the virulent disease just described. This disease prevents the summer damage by the beetles, often killing the larvæ before they have done much injury.

Riley's recommendation to plow badly infested clover under in May rather than to allow it to become a source of contagion, has seldom been followed unless the clover root-borer also has been present, for the leaf-weevil by itself has not often done an immense amount of damage.

The fact that the young larvæ hibernate, led Riley to mention the possibility of crushing them or burning them, but he added his doubt as to the practicability of killing them by rolling or by burning the clover stubble in winter.

The necessity for the employment of any remedy does not appear until the clover is well on in its second year's growth. If damage is anticipated, however, it would seem advisable to pasture the clover lightly or to clip it back in spring; this does not hurt the clover, is highly desirable as a means of forestalling the attacks of some other clover pests, and might check the larvæ of the leaf-weevil somewhat, tho it is possible that they would subsist on the cut stems until the new growth started; and in cold weather they can live a long time without any food.

After the second season red clover should be plowed under to get rid of this and other pests, as well as for agricultural reasons.

Phytonomus punctatus Fab.

1882. Riley, C. V.—Rep. [U. S.] Comm. Agr., 1881–82, pp. 171–179.
Lintner, J. A.—First Rep. Ins. N. Y., pp. 247–253.
1884. Kilman, A. H.—Can. Ent., Vol. XVI., pp. 144, 145.
1896. Webster, F. M.—Bull. No. 68, Ohio Agr. Exper. Sta., pp. 27–31.

CLOVER ROOT-BORER

Hylastinus obscurus Marsh.

(*Hylastes obscurus, H. trifolii* Müll., *Hylesinus trifolii* Müll.)

This pernicious root-borer is gradually spreading over the United States and Canada, and has already ruined crops of clover in New York, Ohio, Indiana, and Michigan. Often the injury done by this insidious insect has been attributed to drought or disease. The injury appears in the wilting and death of the plant. A badly injured plant breaks off easily at the crown; the roots are burrowed out lengthwise, and in the burrows can be found white footless grubs, or little, dark brown, cylindrical beetles, as tough in body as the others of their family, *Scolytidæ.*

Distribution.—This beetle was introduced from Europe, where it has been known for more than a century, feeding chiefly on red clover but also on alsike. In this country it first attracted attention as a pest in 1878 in central New York. Thence it spread westward in the region of Lake Erie, doing great damage in Ontario, Can., in 1888, appearing in Michigan in 1889 at the west end of Lake Erie, and after that spreading over southern Michigan with disastrous consequences. In Ohio it was injurious by 1890, and seriously so in the northwestern part of the state in 1893. It has reached Indiana, Illinois, Pennsylvania, West Virginia, and North Carolina, and has even been reported from Oregon.

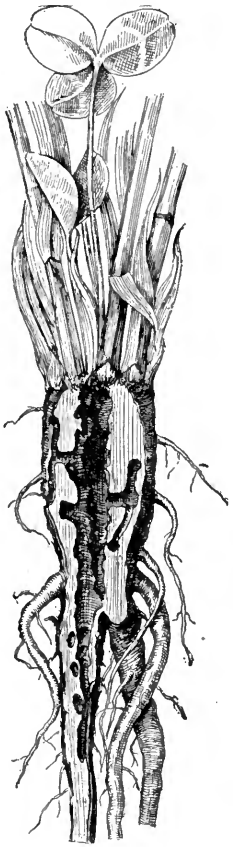

FIG. 17.—Clover Root-borer, *Hylastinus obscurus*; work of insect. (Webster, Circ. 67, Bur. Ent., U. S. Dept. of Agriculture.)

Food Plants and Injury.—In America the chief food plants are red clover and mammoth clover; others being alsike, alfalfa, and the pea.

First-year clover, its roots being small in spring, when the beetle lays its eggs, is not known to be attacked by this borer; second-year clover is attacked; and clover that has been allowed to run for more than two years harbors the pest in abundance.

An affected plant finally wilts and dies; when pulled by hand or by the mower it breaks off at the surface of the ground. The roots of such a plant are burrowed out longitudinally (Fig. 17), the burrows, with their walls more or less decayed, contain the excrementitious particles of the insect, and usually the insect itself in one or more of its stages, tho the beetles, being small, sluggish, and inconspicuous in color, are easily overlooked. Small cylindrical holes thru the sides of the roots are characteristic of this species, as indicating the emergence of beetles.

The amount and rapidity of injury depend not only upon the number of insects present but also upon the amount of moisture received by the plant. In dry weather the plant succumbs quickly to the borer, but in wet weather the plant, tho weakened, may continue to survive. Injured plants are liable to die late in June or early in July, after cutting; tho with plenty of rain many of the crippled plants may live until winter. In 1893 and 1894 the root-borer, in combination with the leaf-weevil and dry weather, caused a general failure of the clover crop in Michigan.

The borer is said to be responsible for an irregular, imperfect blooming of the clover or a failure to bloom at all. If the plants survive, thanks to copious rains, the yield of seed is liable to be almost nothing. In central Illinois the root-borer is generally distributed, but

is not a pest as yet, tho Mr. J. A. West, assistant to the State Entomologist, found alsike injured by it at Monticello in 1907.

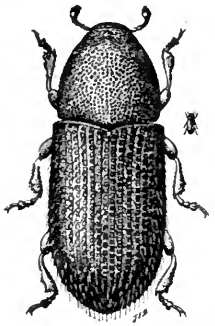

FIG. 18.

FIG. 19.

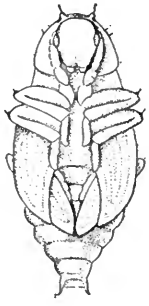

FIG. 20.

Clover Root-borer, *Hylastinus obscurus*: Fig. 18, beetle; Fig. 19, larva; Fig. 20, pupa. Greatly enlarged. (Webster, Circ. 67, Bur. Ent., U. S. Dept. of Agriculture.)

Stages.—The beetle (Fig. 18) is small—at most only 2.5 mm. in length—dark brown or blackish, cylindrical, hard-bodied and hairy. The elytra, or wing-covers, often have a reddish tinge, and are coarsely punctate; and the head and pronotum are more finely punctate, the latter bearing sparse long hairs. The tibiæ have large teeth near the outer end.

The egg is minute, tho visible to the naked eye, white, and elliptical, with a smooth, shining surface.

The larva (Fig. 19) is stout, white, with yellow head and brown mouth parts, footless, and 3 mm. long when full grown.

The pupa (Fig. 20) is white, with a pair of spinelike projections at the extremity of the abdomen, and another pair on the top of the head. The pronotum shows a feeble median ridge and bears a few scattering bristles.

Life History and Habits.—There is but one generation a year. In Ohio, where Webster worked out the life history, the insect winters in clover roots as a beetle and also, tho less commonly, as a larva, the latter pupating in spring. The beetles leave the roots during May and fly about. The eggs are laid mostly from May 15 to June 20 in cavities eaten out by the females in the crown of the plant or down on the sides of the roots. In each cavity the female lays several eggs. Mr. G. C. Davis found females laying eggs inside the root, in the burrows, the eggs being packed into the dead wall of the burrow and covered with refuse. The larvæ, the first of which hatch late in May, feed for a time where they hatched, then tunnel along the roots, making one or more longitudinal galleries with occasional side branches, and filling the burrows with excrement. The pupa is found at the end of a burrow. Most of the larvæ pupate before the first of August and most of the pupæ transform to beetles before the first of October. The beetles

remain in the roots, however, until the following spring, feeding meanwhile, when they are not dormant.

In Ohio, according to Webster, larvæ and adults can be found at almost any time of the year, tho the beetles are rare in July. Pupæ are most common in July, but occur in August and even up to the middle of November, and a few pupæ, newly formed, are met with in early spring. Eggs have been found as late, or as early, as September 18 in Michigan.

Most of our articles on this insect have simply been based on the excellent accounts that Riley, Webster, and G. C. Davis published, and the species needs more study than it has received.

Here in central Illinois the life history and habits are as Webster found them to be in Ohio.

September 9 a pair of the beetles were observed *in coitu* in one of our cages. The conditions were not quite natural, however, for I had taken the beetles from roots and put them on potted clover; out-of-doors they probably would not have left the roots until spring. As soon as they were placed on the plant, September 8, they began to burrow into the crown; they mated the day after; October 3, a long burrow was found, containing several larvæ at its lower end, but no eggs; one of the parent beetles was still alive on November 21.

Only one natural enemy of the clover root-borer has been put on record—a telephorid larva, probably *Telephorus bilineatus* Say, mentioned by Riley as preying on the larva of the borer.

Control.—A badly infested field should be plowed as soon as possible after the removal of the hay crop, in order to starve the grubs by drying out the roots. The plowing must not be delayed, for early in July (latitude of Ohio, Webster) the larvæ begin to pass into the quiescent, or pupa, stage, in which they take no food; then they would doubtless transform and emerge as beetles in some numbers in spite of plowing.

In Ontario, Can., the value of clover as a green fertilizer is so generally appreciated that the farmers do not hesitate to plow the clover under at the first signs of the presence of the root-borer. (Fletcher.)

Another thing: Red clover should not be permitted to straggle along after the second year to furnish a nursery for this pest and others.

Fertilizers do not kill the root-borer and will not save the plant—so Mr. G. C. Davis concluded from his experiments with nitrate of soda, muriate of potash, and kainit. Generally speaking, fertilizers as used against a root-feeding insect act more by stimulating the plant than by affecting the insect directly.

Hylastinus obscurus Marsh.

1879. Riley, C. V.—Rep. [U. S.] Comm. Agr., 1878, pp. 248–250.
1880. Lintner, J. A.—Thirty-ninth Rep. N. Y. State Agr. Soc., 1879, pp. 41, 42.

1894. Davis, G. C.—Bull. No. 116, Mich. Agr. Exper. Sta., pp. 41–47.
1896. Webster, F. M.—Bull. No. 68, Ohio Agr. Exper. Sta., pp. 31–33.
1899. Webster, F. M.—Bull. No. 112, Ohio Agr. Exper. Sta., pp. 143–149.
1905. Webster, F. M.—Circ. No. 67, U. S. Dept. Agr., Bur. Ent., pp. 1–5.

CLOVER HAY-WORM

Hypsopygia costalis Fab.
(*Pyralis costalis, Asopia costalis*)

The clover hay-worm works in stacked or stored clover, eating much of it, and contaminating much more with webs of silk and particles of excrement, making the hay unfit for fodder.

This species, described as long ago as 1775, has been sufficiently infrequent in England to be valued by the collector. It inhabits central and southern Europe, northern Asia, northern Africa, and a large part of North America. In this country its destructive work has been seen in New Hampshire, Massachusetts, Connecticut, New York, Maryland, West Virginia, North Carolina, Ohio, Indiana, Illinois, Kentucky, Tennessee, Alabama, Kansas, Missouri, Iowa, Nebraska, Michigan, and in Ontario, Canada.

In Illinois the species is widely distributed, according to the records of the State Entomologist, and has done no little damage in various parts of the state.

Injury.—The larvæ attack the bottom of a clover stack to a height of two feet or more from the ground; similarly, in the barn, they occur near the floor. They interweave the hay with white silken webs, intermixed with black pellets of excrement resembling coarse grains of gunpowder; they reduce much of the hay to chaff, and their webs give the hay the appearance of being mouldy; in fact, such hay actually becomes mouldy if it has been lying near the ground. This hay is refused by horses and cattle and is fit only to be burnt. When the hay is removed, swarms of wriggling brown caterpillars are left.

The pest evidently prefers dry clover hay. In mixed clover and timothy, the former is eaten and the latter is left, altho 50 percent of such hay may be damaged when the hay is three quarters timothy (Webster). One writer, it should be said, has reported serious damage to pure timothy in Kentucky. Webster reared the larvæ on growing clover heads, in the insectary, and, furthermore, obtained the moth in large numbers (June 3 to July 15) from masses of dead grape leaves taken May 5 on the ground in a vineyard. In summer the caterpillars are confined to the old unfed hay, and the infestation is worst on hay that has lain over, year after year.

Osborn mentions *Pyralis farinalis,* as well as *H. costalis,* as injuring stored clover hay in Iowa.

Stages.—The full-grown caterpillar (Fig. 21) is three quarters of an inch long, and dull brown with an olive tinge usually, tho some of the largest larvæ retain the pale color of the young larvæ. The head, shield, and caudal plate do not turn dark until after the last moult, according to Riley. The thoracic segments are much wrinkled, and most of the remaining segments are each divided by a transverse groove into two subsegments, the anterior of which is the larger. On each segment are several smooth shining areas, each bearing a fine white hair.

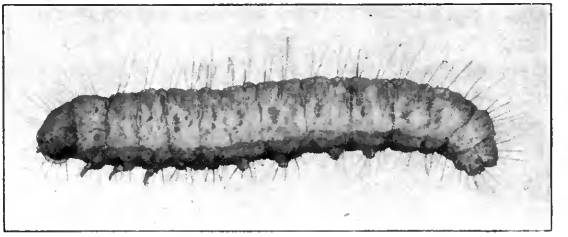

FIG. 21.—Clover Hay-worm, *Hypsopygia costalis,* larva. Greatly enlarged.

The cocoon is half an inch in length, oblong-oval, and composed of white silk, intermingled with excrement and bits of hay.

The chrysalis, as described by Riley, is honey-yellow, with the segments and members clearly defined by the darker color of the "insections."

The moth (Fig. 22) is small—the largest specimens spreading 22 mm.—and has silky wings tinged with purplish above, margined with orange, and fringed with golden yellow. On each of the upper wings are two large golden spots so situated as to divide the front margin of the wing into thirds; each of these spots continues backward to the hind margin of the wing as a narrow lilac line. On each hind wing are two wavy transverse straw-colored lines, one across the middle of the wing, and the other half-way between the first line and the base of the wing. Underneath, the wings are pale yellowish with the markings indistinct. Head and legs straw-colored; antennæ and palpi pale orange, tinged with lilaceous.

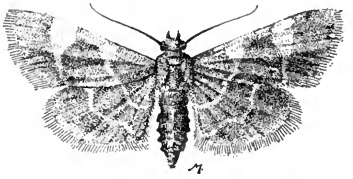

FIG. 22.—Clover Hay-worm, *Hypsopygia costalis,* moth. Twice natural width.

Life History and Habits.—In Missouri and Ohio there are two generations a year and apparently more or less of a third brood. In winter, larvæ of all sizes are to be found in clover hay. In Ohio, Webster found pupæ no earlier than May 25; moths emerged June 12 and laid eggs June 13 to 17, other moths issuing from June 3 to July 15; young larvæ (very small to half grown) occurred July 1; larvæ and pupæ were seen August 6; and adults of the second generation began

to emerge August 8—larvæ from these being found August 15. In Connecticut, pupæ and many grown larvæ occurred June 7 (Britton); a pupa formed June 5 gave the moth June 18; most of the moths disappeared by July 15 (in a certain barn); the first larvæ of the second generation were taken in a stack of clover September 1; and larvæ were not found in barns until two or three weeks later.

In Illinois the hay-worm is destructive in winter and spring, as elsewhere. The records of the State Entomologist refer to its occurrence January 6 at Griggsville; February 4, Midland City; February 18, Shelbyville; March 25, Deland; April 6, Fillmore; May 21, Ridgefarm; and May 27, Parkersburg. A correspondent in Shelbyville reported the caterpillar from cheat, mixed with wheat and timothy.

The office notes include a great many records of the capture of the moths from June 2 onward. June 6, two moths, numerous pupæ, and a great many larvæ were present in a box of infested clover hay received from Parkersburg; and other moths issued June 10, 19, and 20. Dr. Forbes recorded moths of this species as being abundant July 10 to 20 and far less abundant July 28. They disappear about the last of July—those of the first generation—after flying thruout the months of June and July. The moths of the second brood appear a little before the middle of August. Moths are constantly seen from that time until the middle of October, but the last of these perhaps represent a third generation.

In the breeding-cage, eggs may be laid on growing clover heads, as appears from Webster's experiments, hence it is possible that the same thing occurs in the field.

Out-of-doors, the moths are seen flitting about clover stacks at dusk or in cloudy weather (June 29, Ohio). At night they often get into houses and fly toward the lights.

The caterpillars, of all sizes, can be found at any time during the winter, and in a barn they are active when everything outside is frozen. Warmth and moisture are greatest at the bottom of the clover, and there these caterpillars flourish. When you pick them up they are likely to wriggle out of your hand; they can wriggle backward as well as forward. They spin a lot of silk, and construct little silken cases for themselves, as do the clothes moths; they are continually spinning, and are often seen hanging from a thread of silk. These caterpillars are gregarious, or sociable; they gather together while they are feeding, tho they separate and wander when full grown and ready to make their cocoons.

No insect enemies of this pest are as yet known.

Control.—In a barn, old refuse clover-hay should be removed and burned if this insect is present, before new clover is put in. A stack of clover hay should be raised above the ground on a foundation of logs or rails, in order to keep the bottom of the stack as dry and cool as possible. It has been found that salting the hay at the bottom for two or three feet will preserve it from injury. Some farmers habitually salt their clover hay, using about two quarts of salt to the ton.

Webster's experiments indicate that the caterpillars can be killed at once in a clover stack by the use of pyrethrum. He had five tons of clover restacked, dusting it with this insect powder, using ten pounds of pyrethrum to fifty pounds of flour, and found in a sample of the hay that the majority of the caterpillars were dead the day after.

Britton, in Connecticut, tried bisulfid of carbon in a stack and hydrocyanic acid gas in a barn, but in both instances the clover had become packed so solidly that only a few caterpillars—those on the outer part of the heap—were killed by the treatment.

We need to know more about the life history and habits of this insect notwithstanding the large number of articles that have been written on the species, for these, with a few exceptions, add nothing to Riley's original account of 1874.

Hypsopygia costalis Fab.

1874. Riley, C. V.—Sixth Rep. Ins. Mo., pp. 102–107.
1891. Webster, F. M.—Insect Life, Vol. IV., pp. 121, 122.
1894. Davis, G. C.—Bull. No. 116, Mich. Agr. Exper. Sta., pp. 56–58.
1896. Lintner, J. A.—Eleventh Rep. Ins. N. Y., pp. 145–151.
1901. Britton, W. E.—Twenty-fourth Rep. Conn. Agr. Exper. Sta., 1900, p. 314.

CLOVER LEAF-MIDGE

Dasyneura trifolii Löw
(*Cecidomyia trifolii*)

This midge deserves some attention on account of its conspicuous effects on the leaflets of white clover, the leaflet being folded in halves along the midrib to form a sort of pod, which turns yellowish and at length brownish. Within this pod can be found white or orange maggots, or silken cocoons. The maggots change to minute flies—so small and inconspicuous as to interest only a specialist.

The economic importance of the leaf-midge is small, however, and nothing has been added to our published knowledge of the species since Comstock's account of 1880. Some new information appears in the present paper.

The species, long known in Europe, has been recorded from Washington, D. C.; it occurs also in Illinois, and in all probability is present in many other parts of the country.

Food Plants.—The leaf-midge feeds on white clover. In Europe it has been said to affect the undermost root-leaves of red clover, but I have not as yet been able to find it on that plant in this region.

The maggot does not fold the leaflet; the egg is laid before the leaflet has opened out, and after the larvæ begin to work the leaflet remains closed. It grows to a normal size, however, (Pl. I., Fig. 4) and continues to be green for a time, but eventually turns yellowish near the midrib, where the leaflet bulges out here and there, blisterlike.

As the gall gets older the blistered areas become specked with brown, and finally the entire gall turns brown and the leaflet dies. Inside the pod are the maggots—white or orange, according to age—and the white cocoons. The eggs are to be found only between the folded halves of the smallest leaflets, near the ground.

An affected leaflet continues to grow, and its forage value is scarcely diminished, but its death is hastened a little by the maggots. There is no effect upon the plant as a whole; when only one leaflet of a leaf is affected by the insect, the other two remain healthy for an indefinite time, but all three will at length wilt and die a little prematurely.

It can hardly be said that this insect actually injures white clover, taking everything into consideration.

Stages.—The egg has not been described before. It is like that of many other common midges, being elliptico-cylindrical with a slight curvature, colorless and translucent when laid, but showing an internal red spot on the second day—not before—and becoming pale orange in color. Length, 0.3 mm.; width, 0.075 mm.,—on an average. Several eggs are laid, side by side usually, as in Plate I., Fig. 5, in which the variation in the length of the eggs is to be laid to the midge instead of to the artist.

The newly born larva is colorless and transparent, and 0.27 mm. in length; soon it becomes white; when old it is orange (Pl. I., Fig. 6), and when full grown its length is 1.5 to 2 mm. The skin is coarsely granulate. The spiracular tubercles are arranged precisely as in the larva of the clover seed-midge—in fact, this arrangement is the same in several species that I have examined. The form of the sternal spatula (Pl. I., Fig. 7) is, however, different from that of *D. leguminicola,* the only species likely to be confused with this one as it occurs on clover.

The cocoon is oval in general outline, and 1.5 mm. long. Often it is flattened a little from contact with the leaflet or with other cocoons.

The pupa, orange in color, has a darker median ventral stripe, and blackish eyes, as Comstock says. The anterior border of the prothorax is deeply notched, and there are two long, excurved, mesothoracic horns.

Comstock gave a translation of the original description of this midge, which need not be repeated here. Rearing the midge from white clover, there is no difficulty in determining the species. Catching it on the wing, the leaf-midge needs to be distinguished from the seed-midge, which it resembles. Figures 3 and 8 of Plate I. show the differences between the two species. The leaf-midge (Fig. 8) is the smaller of the two, the female measuring 1.6 mm. in length. Both species have the red abdomen, but the dorsal bands of black scales are much larger and denser in *trifolii* than in *leguminicola,* and the scales do not rub off so easily, so that the abdomen in the former species is usually blackish. In addition, the leaf-midge has 14 or 15 antennal

segments, as against 16 or 17 in the seed-midge. The male, distinguishable from the female by the large clasping organs at the end of the abdomen, is also smaller than the male of the seed-midge.

Life History.—The podlike galls (Pl. I., Fig. 4) of the leaf-midge are common on white clover thruout the growing season, during which the insect in one or another of its stages can always be found in some of the galls. Usually several stages in the development of the insect are represented at the same time in a single gall. Frequently one to six individuals inhabit the same gall, and there may be more; I know of twenty eggs being deposited by a single female on one leaflet. Larvæ from eggs laid at the same time do not all develop equally; some of them outdistance the rest, and when the gall is crowded with the maggots, some of them die off in the competition for nourishment.

The earliest date that I have recorded for the galls is June 21, at which time larvæ and cocoons were present; thereafter I found the species in various stages every few days up to October 5, on which date larvæ were common. The latest eggs and larvæ are killed by the frost, along with the leaves which they inhabit. This fact in connection with what we know about the habits of the species warrants the inference that it probably winters in the cocoon, tho possibly as a fly.

My observations indicate four full broods a year in this place, with scattering and ill-fated members of a fifth brood. Each generation requires about one month, on an average, for its development. In the field the broods overlap enough to make their separation by field observations a little difficult. Yet there are times when almost all the galls are empty, indicating an interval between two broods, when the species is represented almost entirely by winged adults. Thus, August 14, 1903, when I examined a great number of recently made galls, I found 85 without living contents, tho remnants of cocoons were often present; 9 with cocoons (one to four in each instance); 2 with full-grown or large larvæ; and 2 with larvæ that had just hatched. Again, August 15, 1907, I opened several hundred of the galls and found nearly all of them to contain cocoons or full-grown larvæ; only one or two had white larvæ, and very many of the galls were empty, tho not more than a month old. Thus a break between two generations occurred about August 15 in two years.

Eggs laid August 1 gave six larvæ, the flies from which issued August 22; this is the shortest life history that I have found for this species. The egg period is six days as a rule; thus, eggs laid August 13 (2:45 to 3:15 p. m.) hatched August 19 (at noon). The period in the cocoon varies. From two cocoons made August 3, the imagines emerged August 13; in several other instances, nine days was the period. On the other hand, a larva that was making a cocoon August 5 did not give the adult until August 27.

Habits.—The midges can be obtained simply by picking the galls and keeping them on damp sand or cotton-wool. A better way, however, is to transplant such plants as bear the galls, because the leaves do not keep fresh very long after being picked.

To get the eggs and the subsequent stages it is only necessary to turn a lot of the midges loose on potted white clover under a lamp chimney (the narrow cylindrical kind) covered at the top with netting, making sure that the plant bears some young unopened leaves. It is best, also, to cut off most of the old leaves, especially in order to facilitate observation.

These little flies mate readily under such conditions, and lay eggs freely, as I have several times observed. After coition, which may not last longer than a minute, oviposition occurs within an hour or so. The female either drops to the ground or alights on the plant and walks downward. In either event she finds, after more or less exploration, a young leaflet still folded in halves. Standing at the base of this, she wriggles her long flexible ovipositor in between the two contiguous faces of the leaflet as far as possible; at intervals a slight wave of distention passes back along the ovipositor, indicating probably the passage of an egg. Usually several eggs are laid on the same leaflet—sometimes a dozen or more. After many eggs are laid, the abdomen of the female is noticeably smaller.

In some way the insect prevents the leaflet from opening out. The larva is quite unable to fold a leaflet that has already spread out. If placed on such a leaf the larvæ cannot even hold on to it, and rolls off. Like other midge larvæ, they require some tight crevice in which to develop.

Like them also, the maggots of the clover leaf-midge are very sensitive to moisture, contracting and becoming motionless when it is dry, and resuming activity when it is moist. Dryness prolongs the period of development and retards the emergence of the fly. The long record just given of twenty-two days from cocoon-making to emergence was due in some measure to dryness. The larva found making a cocoon August 5, was put into a small glass-covered box and pressed up against the glass by means of dry cotton-wool, so that I could watch the process of cocoon formation under the microscope. The larva spun for awhile, and then left its cocoon unfinished and wandered about, but it was contracted and motionless August 6 to 11. On the latter date the cotton was moistened, and soon the larva began to wriggle about in all directions, away from the light, and kept this up all day. Coming to rest again, the larva contracted without making a new cocoon, and gave an imago August 27. The larva often pupates without making a cocoon, if taken out of its gall.

The cocoon is evidently composed of silken threads, as Comstock said. Under the microscope the thread can be seen to issue from the mouth of the larva, which swings the fore part of the body to and fro as it spins. This fact is mentioned to counteract the old statement that the cocoon is an exudation around the body of the larva.

The leaf-midge is not without natural enemies. I have found the larvæ and pupæ of a chalcid in the galls among the midge larvæ. The chalcid is not common; I found it in only 1 percent of the galls, out of hundreds examined. The chalcid larva might hastily be mistaken

for one of the midge larvæ, as it has much the same size and color—white or orange. Its body is not so blunt as that of the maggots, however, and tapers anteriorly. Furthermore, the chalcid larva is far more active than a midge larva. While the latter wriggles about sluggishly and aimlessly, the former wriggles along hurriedly, as if it had some end in view. A few times I have seen a chalcid larva attack and feed upon a maggot of the midge, it being predaceous instead of parasitic. The chalcid becomes a naked pupa within the gall, among any of the maggots that may have escaped its attacks.

The clover leaf-midge needs no discussion from the point of view of control. Where the clover is frequently pastured or cut (as on lawns) it is hard to find any signs of the leaf-midge.

Dasyneura (Cecidomyia) trifolii Löw

1880. Comstock, J. H.—Rep. [U. S.] Comm. Agr., 1879, pp. 197–199.

CLOVER CALLIPTERUS

Callipterus trifolii Monell

This aphid is common in our clover fields every year, but has not been destructive as yet. It is far less numerous than the large green aphid, *Macrosiphum pisi,* and is not wide-spread and gregarious like that species, but is scattered, and rather solitary in habit.

C. trifolii, as found on clover, will be recognized, generally speaking, as a small yellowish green or yellow species with six longitudinal rows of dark tubercles on the abdomen.

This species has received almost no mention in our literature, largely because it has done nothing to attract attention. The material which we studied was determined tentatively by me from the original description, and positively by the author of the species, to whom specimens were sent by Mr. J. J. Davis.

Callipterus trifolii was described from Washington, D. C., by Monell, who found it again in Missouri. It is common in Illinois, and is reported authentically from Iowa, Kansas, Minnesota, North Dakota, New York, Delaware, and Virginia.

Descriptions.—The following descriptions, sufficiently detailed for the recognition of the species, and supplementary to the original description, are adapted from manuscript descriptions made by J. J. Davis, in cooperation with Monell.

The *viviparous females* (whether winged or not) are pale yellowish green. Eyes dark red to brown. Antennæ pale greenish basally, dusky apically, faintly imbricate, and as long as or a little longer than the body. Legs pale, dusky at the joints; tarsi blackish. Abdomen with six longitudinal rows of dusky setiferous tubercles. Style globular; cornicles tubercular; both a little dusky.

In the *wingless viviparous female* (Pl II., Fig. 5) the dark abdominal tubercles bear conspicuous capitate hairs, and the length of the female averages 1.6 mm.

The *winged viviparous female* (Pl. II., Fig. 6) has a row of ten to twelve sensoria on the third antennal segment. Wings hyaline; veins dark brown to black, narrowly bordered with brownish, with a small brown patch at the outer end of each vein; basal half of stigmal vein obsolescent; discoidals as in the figure. The abdominal tubercles of the two inner rows are oblong, and each of them bears two fine setæ. The remaining tubercles, more or less circular, have each but one seta. Average length, 1.4 mm.

The *wingless oviparous female* is at first pale yellow, but the abdomen (excepting the last two segments) becomes progressively orange as the eggs develop in the body, and the orange color may eventually extend over most of the thorax. Eyes black. The antennæ do not reach to the cornicles, and the third antennal segment has eight or ten circular sensoria. Hind tibiæ swollen, and with sensoria. Dorsal abdominal tubercles essentially as in the winged viviparous female. Average length, 1.8 mm.

In the *winged male* the head and thorax are pale olivaceous green, and the abdomen pale yellowish green, with conspicuous black dorsal spots. Antennæ black (excepting the first two segments) and as long as the body, with sensoria as follows: 12–15 on segment three; 2–4 on four; 3–5 on five. Wings essentially as in the female. The large black oval setiferous spots of the abdomen fall chiefly into four rows—two dorsal and two lateral, with scattered spots between the former and the latter, on each side. Style and cornicles dusky. Average length, 1.2 mm.

The absolute lengths of the segments of the antennæ and legs, as well as those of the cornicles, are, as in other aphids, too variable to be of much importance as specific characters. The relative lengths are more constant, however, and hence more important for the systematist. They appear from the following table, which consists of the averages of many measurements made from Urbana specimens by J. J. Davis and from types of Mr. Monell—made by himself.

C. trifolii

	Antennæ						Style	Cornicles
	I	II	III	IV	V	VI		
Wingless viviparous female	.07 mm.	.05	.51	34	.31	.15+.16	.17	.06
Winged viviparous female	07	.05	.51	.36	.32	.16+.16	13	.06
Winged viviparous female, Monell's types	.05	.04	.44	31	.28	.15+.13		
Wingless oviparous female	.07	.05	.40	.19	.20	.13+.14		.06
Winged male	.06	.05	.51	30	.29	.15+ 15		.04

The egg, hitherto undescribed, is much like that of any other aphid in being elliptical, 0.57 mm. long, and 0.25 mm. broad, but has a characteristic bright orange-color when recently laid.

Life History, etc.—This aphid winters as an egg in the vicinity of Urbana, and I have found as yet no evidence that the female hibernates. The course of the life history differs but little from that of other aphids. The eggs produce viviparous females, and these constitute the successive generations up to the end of the season, when winged males and wingless oviparous females are brought forth viviparously. In this species, a large proportion—if not the majority—of the viviparous females are winged.

Beginning with a viviparous female which issued from the egg March 27, Mr. R. L. Webster followed the successive generations thru the season and obtained a maximum of nineteen, the final generation appearing October 18, in the insectary. The individuals of this generation were still very small on November 11, and disappeared thereafter. The more important of R. L. Webster's observations are given in the following table.

C. trifolii

Generation	Birth	Maturity	Death	Days to mature	Days of life	Number of young
1	Mar. 27	Apr. 20	May 9	24	43	36
2	Apr. 21	May 3	May 21	12	30	21
3	May 6	May 18	May 26	12	20	34
4	May 15	May 30	June 12	15	28	25
5	May 30	June 7	June 19	8	20	46
6	June 7	June 15	June 21	8	14	25
7	June 15	June 22	July 7	7	22	55
8	June 24	July 3	July 3	9	9	13
9	July 3	July 12	July 18	9	15	13
10	July 13	July 18	July 31	5	18	34
11	July 19	July 29	Aug. 3	10	15	23
12	July 29	Aug. 5	Aug. 22	7	24	70
13	Aug. 5	Aug. 11	Sept. 2	6	28	75
14	Aug. 11	Aug. 21	Sept. 9	10	29	60
15	Aug. 21	Aug. 28	Sept. 11	7	21	36
16	Sept. 10	Sept 18	Sept. 28	8	18	20
17	Sept 19	Oct. 2	Oct. 9	13	20	6
18	Oct. 2	Oct. 18	?	16	40+	?
19	Oct. 18	?	?	?	24+	?
Averages.....				10	22	34.8

The averages are made from the first seventeen generations. The number of young produced per day by one female ranges from none to thirteen, with an average of 3.7; and the bearing period of the female averages 12.1 days.

Comparing this table with that for *M. pisi* (p. 142) slight differences are apparent in the length of life and the period before maturity. These differences are of no weight, however, in view of the great variability of both species in both these respects. A few more observations would have changed, one way or the other, these averages, which are so nearly alike. The averages show, rather, that *M. pisi* and *C.*

trifolii agree essentially as regards the time from birth to maturity, the bearing period, and the length of life, the number of generations being essentially the same in both species. *C. trifolii* produces, however, only half as many young per day as *M. pisi* (3.7 young as against 6), and this difference serves to account for the relatively smaller numbers of *C. trifolii* in the field compared with *M. pisi*.

Wintered eggs hatched March 27, 28, and 29, according to our notes.

On red clover, brought into the laboratory in November, and grown, there were found, January 29, a large number of the orange oviparous females, which laid eggs in profusion. The average number of eggs in the abdomen of the mother is ten, as found by J. J. Davis.

The fungus *Empusa aphidis* attacks this plant-louse thruout the season, in damp weather, just as it does *M. pisi*; and many of the insect enemies of the latter species attack *C. trifolii* also.

Callipterus trifolii maintains its existence every year, but has always been a sporadic species.

Callipterus trifolii Monell.

1882. Monell, J. T.—Can. Ent., Vol. XIV., p. 14.

1908. Davis, J. J.—Ann. Ent. Soc. Amer., Vol. I., pp. 256–258.

CLOVER STEM-BORER

Languria mozardi Latr.

The stem-borer is of but secondary importance among the injurious insects of clover; it has never been a pest, so far as I can learn.

The slender yellow larva eats out the pith of the clover stem, making a long burrow, with brown discolored walls. The entire development takes place within the clover stem, and the adults fly abroad as slender beetles with dark blue wing-covers, and red thorax and head.

Tho the beetle is well known to collectors, scarcely anything has been published on its life history since Comstock's brief account in 1880.

Distribution.—This species was originally described from North America, and the genus *Languria* does not appear in the catalogs of European beetles. In this country *L. mozardi* has been reported from Pennsylvania, the District of Columbia, Indiana, Illinois, Michigan, Kansas, Nebraska, and elsewhere. Generally speaking, it inhabits the middle and the southern states, some of the western states, and parts of Canada.

Food Plants and Injuries.—The clover stem-borer is by no means limited to red clover and mammoth clover, but feeds also on the following plants, as C. M. Weed, Chittenden, and Webster found: wild

sweet clover *(Melilotus alba),* pink fleabane *(Erigeron philadelphicus),* daisy fleabane *(E. ramosus),* mare's tail *(E. canadensis),* ragweed *(Ambrosia trifida),* coneflower *(Rudbeckia laciniata),* yarrow *(Achillea millefolium),* oxeye daisy *(Chrysanthemum leucanthemum),* thistle *(Cnicus altissimus),* wild lettuce *(Lactuca canadensis* and *L. floridana),* bellflower *(Campanula americana),* nettle *(Urtica gracilis* and *U. dioica)* and timothy *(Phleum pratense).* Most of these are *Compositæ,* it will be noticed, and nearly all are weeds.

Injury.—The beetles do not lay their eggs in seedling clover, but find clover that is more than one year old and select only the larger stems of that.

By autumn, red clover sown in spring has developed stems of considerable size, and the beetles are present—but they do not lay eggs in autumn, in my experience.

The larva, by eating the pith, hollows out the clover stem, making a long burrow, the walls of which turn brown. By cutting stems across, beginning near the ground, and looking at the cut ends, one can see whether the pith is white and solid or whether it has been eaten out by this borer. The larvæ eat usually nothing but the pith, which happens to be the part that the plant can best afford to lose.

Comstock wrote, "While they do not kill the stem outright, they gradually weaken it and eventually cause its destruction, having also, of course, a very injurious effect upon the maturing of the seed." Undoubtedly the insect is injurious, but it is not so injurious as might be supposed. The loss of the pith may affect the nutrition of the plant to some extent, since the pith contains reserve food-material in the form of starch. The chief effect of the stem-borer is, however, a mechanical one. The stems that are hollowed out fall to the ground prematurely, tho not until they have attained a considerable size. One can find the borers most abundantly in the large prostrate stems rather than in the stems that remain erect. The plants that lodge carry their flowers to the ground, become soiled with dirt, and are not easy to mow. Mammoth clover, running far into the season, lodges badly from the work of the borer; while medium red clover, if cut when it should be, escapes practically all injury from this insect.

Rarely the borer occurs in a small soft stem and causes it to wilt: for in such a stem the larva eats not only the pith, but also some of the adjacent ducts, thru which water is conveyed up the stem to the leaves. In old stems these ducts are too tough to be eaten by the larva.

Were this insect more numerous it might gradually develop into a pest of considerable importance. It is most common on clover, but has to its credit the fact that it affects also a considerable number of weeds.

July 6 we found 41 percent of the old stems to be infested by this borer. This was in the hay crop—as yet uncut. On the same day we examined 61 new stems—the second growth after cutting—and found two egg pits as the only signs of the borer. The beetles

had disappeared, almost without exception, by this date. July 7, 43 percent of the old stems, taken from many different places—roadside as well as field—contained the insect.

Stages.—The beetle (Fig. 23) is conspicuous on account of its slender form, dark blue wing-covers, and shiny red head and thorax. Length 4 mm. to 7.8 mm. In *Languria mozardi,* as distinguished from other species of the genus, the antennæ are black, with the club five-segmented; the legs are red, with the outer half of the femur black and the tibiæ and tarsi often more or less dusky; last three abdominal segments black, the abdomen otherwise red; elytra rounded at apices, not sinuate, punctate-striate with the interspaces impunctate; scutellum red; head and thorax sparsely punctate.

FIG. 23.

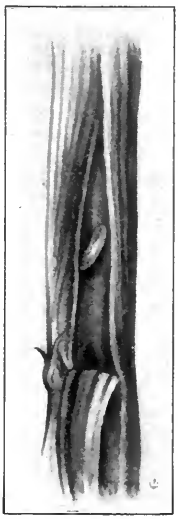

FIG. 24.

Clover Stem-borer, *Languria mozardi*: Fig. 23, beetle, greatly enlarged; Fig. 24, egg, in natural position, four times natural length.

The egg (Fig. 24) is translucent cream-yellow, paler at each end, elliptico-cylindrical and slightly curving, with one end slightly more tapering than the other. One specimen was 1.5 mm, long and 0.3 mm. broad; another, 1.9 mm. by 0.5 mm.

The larva (Fig. 25) is slender, subcylindrical, 8 mm. long and 0.9 mm. wide when full grown, and light yellow, with a pair of brown curving anal hooks. The thoracic legs are well developed and there is a single anal proleg. Comstock gives other details. At birth the larva is 2 mm. long; when four days old, 3 mm.; nine days, 5 mm.; full grown, as above.

The pupa (Fig. 26) is yellow, slender, has a large head, and is 6 mm. long.

Life History.—There is but one generation a year in this latitude. Here the species hibernates as a beetle. We have kept it alive over winter. It may also winter as a larva, as Chittenden found larvæ

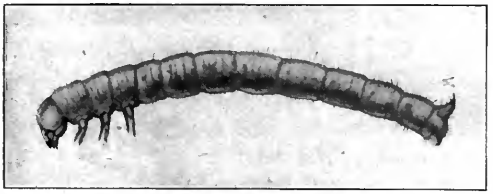

FIG. 25.

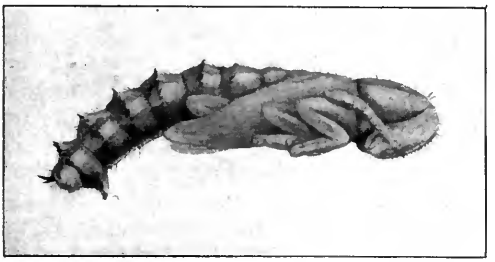

FIG. 26.

Clover Stem-borer, *Languria mozardi*: Fig. 25, larva; Fig. 26, pupa. Both greatly enlarged.

remaining as such from November to April, in stems of ragweed. In late winter and early spring the beetles are to be found in red-clover fields under the rubbish on the ground. In spring they eat clover leaves to some extent, but do no conspicuous damage, as they are comparatively few. In May and June these beetles mate; by July 10, nearly all of them have died off; rarely does one of the wintered beetles survive into August. Young larvæ are common in the clover stems in the last week of June and early in July, for the most part; tho eggs are not uncommon early in July, and occur, rarely, as late as July 17. Larvæ of all ages are common in clover stems in July and thereafter; pupæ are most numerous about August 15; and the beetles of the new generation emerge from the first of August up to the middle of September, if not later. After the autumn frosts the beetles are to be found on the ground under the debris.

Such is the life history, in condensed form, for this insect in this part of Illinois. Some details of importance follow.

Eggs laid May 19 hatched May 24; those laid July 14 hatched July 17. The egg period was three days also in the case of eggs that hatched July 8, 9, and 10. Eggs were taken in large numbers in the field July 5, 6, and 7, at which time 20 percent of all the large clover stems examined contained each an egg. In one field 41 percent of the clover stems, taken at random, had egg pits July 6, with either eggs or small larvæ present.

Beetles that had hibernated, died in the insectary July 5, 9, and 26, after having been kept there with proper food, etc., since winter. By July 5 most of the beetles are gone from the fields; only a few stragglers continue to live, there being a conspicuous break between the last of the wintered beetles and the first beetles of the new generation. Larvæ, nearly or quite grown, and pupæ are common in old clover stems July 28 to August 7. About July 30 the larvæ are three times as numerous as the pupæ; but after the first week in August the latter exceed the former in number. The new beetles emerge mostly thruout August and during the first half of September. In the insectary they issued almost every day from August 3 to September 14, and one emerged September 20. Most of them have issued by August 26, however. At that date the burrows are almost all vacant, and the beetles are abroad in the field, feeding a little, seeking shelter at every cold spell, becoming more and more sluggish, and finally dormant. Not until spring does the reproductive instinct awaken.

Habits.—Oviposition occurs to some extent late in May and early in July, but for the most part in June, and has been witnessed in the daytime. The female gnaws a small pit on the stem of a plant, as Chittenden and others have observed. On clover stems these pits can be found easily. Unless freshly made, the pit is brown, in contrast to the green of the stem; a pit that is green is less than twenty-four hours old, and indicates, as a rule, the presence of an egg. The egg-pit is shallow, oval or round in outline, and not more than one sixteenth of an inch in length. In the center of the pit a minute linear or elliptical slit opens into the pith. Upon cutting open the stem, the egg is seen on the inner wall of the stem, often opposite the pit, but sometimes as far from it as four to six millimeters. The female makes the pit with her mandibles, then pushes the end of the abdomen thru the bottom of the pit and into the pith, these operations taking eight minutes in one instance and sixteen in another, as observed by E. O. G. Kelly. Sometimes a female gnaws out a pit without laying the egg. In red clover the eggs are laid singly, almost invariably, in my experience, rarely two being found together. In another plant (*Leucanthemum*), however, Mr. Girault saw at least fifteen eggs deposited in the same nidus (Ent. News, Vol. XVIII., pp. 366, 367).

The egg-pits occur on the main stem of a red clover plant anywhere from three to twenty inches from the ground, averaging ten inches, the old pits having been carried up more or less by the growth of the stem. Fresh pits, especially those on small stems, are usually not far from the ground.

The larva, feeding on the pith (Fig. 27), tunnels out the main stem for sometimes two feet. If two larvæ occupy the same stem their combined efforts may produce a burrow as long as thirty-two inches, extending from the main stem out into one of the larger branches. The largest larvæ and the pupæ (Fig. 28) are found usually at the lower end of the burrow, an inch or two from the ground, the pupa

with the head upward. The beetle (Fig. 29) after issuing from the pupa lingers in the burrow for a while, and then escapes by gnawing a round hole straight thru the wall of the stem. These exit openings are rather conspicuous.

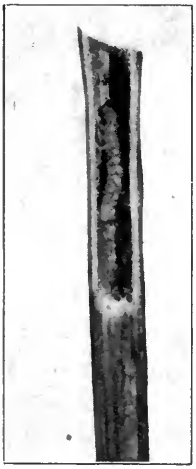

FIG. 27.

FIG. 28.

FIG. 29.

Clover Stem-borer, *Languria mozardi*: Fig. 27, larva, in clover stem; Fig. 28, pupa, in same,—both twice natural length; Fig. 29, beetle, on clover stem, slightly enlarged.

Natural Enemies.—Comstock mentioned two parasites that he found in the burrows of this stalk-borer: a small black chalcid, with a dark naked pupa; and a yellowish ichneumonid, the pupa of which is enclosed in a delicate white silken cocoon. C. M. Weed gave a figure and made brief mention of such a chalcid. I have found the chalcid —probably the same one—in considerable numbers by examining an immense number of stems. The egg of the parasite is found beside that of the stem-borer, and hatches a little later than the latter egg. The chalcid larva bites into the *Languria* larva and feeds upon it as an external parasite. Now and then the chalcid larva detaches itself from its host, but finds the latter again whenever necessary. The *Languria* larva dies; the parasite survives and becomes a naked pupa in the burrow, from which the adult emerges by cutting a minute round hole thru the wall of the stem.

Eggs, larvæ, and pupæ of the parasite were most frequent in the burrows July 6 to 8. The adult chalcids issued from July 11 to August 5,—most numerously, however, in the last week of July. August 26 nearly all the *Languria* burrows were empty, and the stems showed the exits of the host and those of the parasite.

An ichneumonid cocoon taken in a *Languria* burrow by me August 7 gave the adult August 11.

Neither of these species has been determined.

Control.—The clover stem-borer has not yet attracted much attention as an injurious insect. Such effects as it produces are not of the violent sort which attract notice. For a time I was in doubt as to whether the lodging of the plants was due in any degree to this insect; later, I found that affected stems do not lodge until they get large, but then fall sooner than unaffected stems.

Every year the farmer unknowingly kills off large numbers of these insects when he cuts his hay crop, whether he cuts it early or late, for in the latter part of June and thruout July in this latitude the great majority of the insects are inside the clover stems as larvæ or pupæ. The old beetles from the previous year are practically gone by July 5, and the new beetles do not issue from the stems until about the first of August. If the cutting of the hay crop is neglected, however, and left far into July, much of the clover will be flat on the ground from the work of this insect. I had this tested on the university farm, and when the clover was cut, heard, from the man who mowed the field, certain appropriate comments upon the amount of clover which had lodged.

If the red clover is cut when it should be—to make the best fodder—only about three stems in one hundred of the new growth will show the insect. To find many larvæ in July and early August one has to search in uncut field-clover, or in clover growing wild on the border of a field or by the side of the road or the railroad track. The practice of mowing and destroying volunteer clover is well worth the little time that it takes.

Languria mozardi Latr.

1880. Comstock, J. H.—Rep. [U. S.] Comm. Agr., 1879, pp. 199, 200.

1881. Lintner, J. A.—Fortieth Rep. N. Y. State Agr. Soc., 1880, pp. 18–20.

1890. Weed, C. M.—Amer. Nat., Vol. XXIV., p. 867.
Weed, C. M.—Bull. Ohio Agr. Exper. Sta., Sec. Ser., Vol. III., No. 8, pp. 235–238.
Chittenden, F. H.—Insect Life, Vol. II., pp. 346, 347.

CLOVER SITONES

Sitones flavescens All.

This small brown curculio eats the leaves of clovers and alfalfa, and its white footless grubs feed at the crown or at the roots of the same plants. It has rarely been reported as injurious in this country, but needs to be watched, nevertheless.

The species is abundant in the Atlantic states, especially near the seashore, is on record from Indiana, Illinois, Iowa, and Minnesota, and doubtless has a much wider distribution. Everything indicates that it came from Europe, where this and other species of the genus are injurious to clover and lucerne (alfalfa).

Food Plants and Injuries.—White clover, alsike, red clover, and alfalfa are known to be eaten freely by this insect. In Europe another food plant is the grass *Poa annua.* Webster found a strong preference for white clover and alsike over red clover in Indiana. Osborn and Gossard found red clover to be eaten readily in Iowa. Here in Illinois red clover is commonly eaten, but white clover shows rather more of the injury. Alfalfa is also eaten to some extent. The beetles eat at the edges of the leaves, and the larvæ feed at the roots or the bases of the stems.

The leaves are bitten out in a characteristic manner, on acount of the methodical feeding habits of the beetle. On an expanded leaflet the beetle eats inward from the margin, making a small hemispherical or U-shaped gap. The symmetrical injury, shown in Figure 30, is, however, frequent, as the beetle often, if not usually, selects a young tender leaflet that is still folded in halves along the midrib, and notches out both margins at once; or it may bite out a hemispherical notch at the midrib, resulting in a round hole when the leaflet opens. When

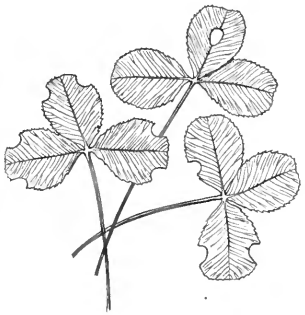

FIG. 30.—Leaves of white clover showing characteristic injury by beetle of *Sitones flavescens.* Natural size.

FIG. 31.—*Sitones flavescens.* Greatly enlarged.

all three of the folded leaflets are as yet side by side, the beetle at one operation produces the effect shown in the leaf at the left in Figure 30. A single notch constitutes a meal, whether the beetle happens to eat one thickness of the leaf or six.

The youngest larvæ work at the bases of the stems or the bases of the roots, tho most of the injury by them is done on the roots. A few of these larvæ, biting out the roots near the crown, can cause a plant to wilt, even tho no other insect is present.

Aside from the serious injury done to white clover and the attacks upon alsike in Indiana in 1885, as reported by Webster, this species has not put itself on record as an injurious insect in this

country. In Europe, however, it has now and then shown what it is capable of doing in the way of damage.

Stages.—The beetle (Fig. 31) is a small dark brown or rusty brown curculio, 5.5 mm. in length, with the beak short and broad. It is distinguished from other species of the same genus by the absence of erect setæ on the interspaces of the elytra, and by its minute, narrow, hairlike scales. On fresh specimens the pronotum shows a pale median dorsal line and a pale stripe on each side, the lateral stripes being continued forward on the head, above the eyes, and along the beak; and also backward on the elytra for a short distance.

In the genus *Sitones,* of which we have several species that are potentially injurious, the mandibles are stout, convex on the outside, and roughly punctured; and the antennal grooves extend forward to the bases of the mandibles,—not to mention other characters given by Le Conte and Horn, and also by Casey. As in other *Curculionidæ,* the male has one more "dorsal segment" than the female, owing to the division of the pygidium into two segments.

The egg is subspherical, yellowish white at first, turning greenish, and becoming black in two or three days. The diameter is nearly 0.4 mm., tho the egg is a trifle longer than broad.

The larva, 5 mm. long when full grown, is a stout, yellowish white, footless grub. The head is small and yellowish brown, with whitish lines. Body segments a little larger than the head; the second and the third a little larger than the first. The legs are represented by fleshy double tubercles. The abdominal segments gradually decrease in size and bear longer hairs than the thorax, these being longest on the small ninth segment, which terminates in a short, stout, truncate pseudopod.

The larvæ assume a hooklike position, as mentioned by Webster, the head and thorax making almost a right angle with the abdomen.

The pupa, 5 mm. in length, is pale yellowish, bearing hairs, spinules, and tubercles. The abdomen gradually diminishes in size, and the segments bear a few short reddish spinules, transversely arranged; the ninth segment has also two long, slender, converging lateral spines, whitish basally and reddish apically, and toothed near the middle. The pupa and the larva have been described in minute detail by Xambeu.

Life History.—Scarcely anything on the life history of this species has appeared in our literature since Webster's useful article of twenty years ago. In central Illinois the general course of the life history is markedly like that of the clover leaf-weevil. There is one generation each year. The beetles live thru summer and autumn, and try to hibernate. The eggs are not laid until late in the season, but they hatch in the same season and the little larvæ hibernate.

March 23 I saw the characteristic signs of the beetle on one red clover leaf, recently expanded, and again March 28, on white clover. The beetles are rare, however, in spring, and the earliest record that

I have of actually finding the beetle is June 19. This may have been—and probably was—one of the new brood, the adults of which are not uncommon in the last week of June and become common by the middle of July. They emerge over a considerable period, as our records show, our dates of emergence being July 10 and 16, and August 20 and 25. The pupal period is two to three weeks. Thru July, August, and September the beetles are common in the field, where we have found them as late as October 8, 14, and 31, and November 25; and indoors, they may be kept alive far into the winter and doubtless until spring. Like the clover leaf-weevil, these other curculios feed for a long time before mating and laying eggs. Dates of coition are July 1 (exceptionally early); August 26, 30, and 31; September 1, 8, 10, 15, and 27; October 10, 18, and 25; and November 14. All these records except those of September 8 and 10 were made in the insectary (unheated but yet affording some protection from frost), and out-of-doors mating and oviposition would not occur for quite so long a time. Two to ten days elapse between coition and egg-laying. In the field most of the eggs are laid in September. Indoors we have found them to have been laid September 12, 14, 15, 19, 20, 22, 25, 26, 27, and 29; October 23 and 27; and November 1, 2, 3, 4, 5, 10, 14, 16, 17, and 23. For several years we have kept the beetles in abundance under daily observation thruout their long lifetime, without getting other dates of oviposition than these. A single female lays her eggs at irregular intervals extending over several weeks. Thus a female which copulated October 25 laid eggs October 27, November 2, 10, 17, and 24. The egg period varies, even under conditions apparently the same, and ranges from 13 to 32 days. Hatching occurred in the insectary from October 17 to November 29, mostly in November, and most of it before winter. Not a few eggs, however, failed to hatch in autumn, and did not hatch the following spring, when they were evidently dead. There remains, nevertheless, the possibility that some eggs survive the winter.

The species winters chiefly as a young larva, but occasionally survives as a beetle in this region.

Webster dug up frozen clover sod on December 9, at Lafayette, Ind., and found therein, after thawing it out, *Sitones* larvæ, some of them 1 mm. long, most of them under 2.5 mm. in length, and two full grown and in earthen cells. He found also two beetles, but no pupæ. One of the adults was still alive February 18. April 13 he found in the field, larvæ (less numerous than in December, and in about the same stage of growth), no pupæ, and two beetles, which died soon afterward. May 25 he obtained larvæ (less numerous than in April, but now nearly or quite full-grown) and pupæ, and a single adult, which died May 30. These beetles laid no eggs. June 14 he found several adults. I regard these as belonging to the new brood.

Webster's account serves almost exactly for the species as it occurs here in Urbana. He found, however, that eggs laid October 17 and 25 hatched in about 48 hours at a temperature of 65° F.—a much

shorter period than any that we have as yet found. He notes eggs as being laid as soon as August 7, and copulation as occurring in the field as late as November 12.

Habits.—One or two beetles manage to live over winter, and even to eat a little in early spring. Probably they issued late in the previous season and had enough vitality to carry them over to the next season. I do not believe that such beetles lay any eggs in spring, however, in this locality.

When the larvæ emerge from the egg in autumn they feed on tender green tissue down where the stems join, avoiding the light and biting out little crevices, in which they lie. As it gets colder, they go down deeper and reach the roots. The larger larvæ and the pupæ are found on the roots, and part of the eggs are laid there, some of the female beetles, after copulation, burrowing down along the roots. Other females, in the breeding-cage, drop their eggs promiscuously.

The beetles, like the larvæ, avoid bright sunlight. Most of them feed by night. Some feed, to be sure, in the daytime when the sky is overcast, or even in bright daylight on a shaded portion of a plant. To find many of the beetles during the day, however, one must scrape away the rubbish on the ground near clover plants that show the characteristic work of the insect. The beetles when exposed to the light are quick to recover their wits, and to hurry off to another sheltered situation.

The beetle when engaged in feeding stands astride upon the edge of a leaflet and stays in the same spot, swinging its head and thorax up and down as it eats, and biting out a rounded gap always of about the same form and size. The beetles are alert when feeding, and drop to the ground without hesitation when approached incautiously. Indoors they will feed in the daytime if the light is not too strong.

Control.—No enemies of this species have been found up to the present. Should it become destructive it would be hard to deal with. The cutting of the hay crop has little or no effect upon the larvæ or the beetles; the former continue to feed on the roots, and the latter feed temporarily on the green stubble and attack the new leaves as soon as they appear. In a field of red clover cut July 1, I found the beetles and larvæ common July 15; on clover cut July 23 the new leaves showed considerable injury July 30.

Fortunately it is not necessary as yet to prescribe remedies for the attacks of this weevil.

Other Species of Sitones.—In Europe several species of *Sitones* are injurious to clovers and allied plants. In America we have at least four of the European species, namely, *flavescens, tibialis, hispidulus,* and *lineellus. Tibialis* is of no economic importance here. *Hispidulus,* according to Schwarz, is a recent importation. It was first noticed in 1876 in New Jersey, and subsequently in New York, Maryland, and Pennsylvania. The species is injurious in the old country and may become a pest here. Schwarz found it to be abundant in 1889 in Washington, D. C., feeding on red clover.

Lineellus is another potential pest, having injured clover and alfalfa in Europe, tho it is not common here as yet. In Urbana, it occurs occasionally in red clover fields, and the beetle eats the leaves of that plant. A female taken November 26, 1907, by Mr. R. D. Glasgow, a student at the University of Illinois, was kept alive on clover leaves for a long time, under daily observation, and laid eggs, eight being found November 27, and 10 on November 30. These are oval, pale translucent yellow when laid, becoming jet-black; surface minutely granulate; length, 0.5 mm.; breadth, 0.38 mm. Five of the eggs found November 27, and laid not before November 26, hatched December 16. The larva at hatching is white, stout, and footless, with a black head, and its length is 0.82 mm. The body is wrinkled to such an extent as to obscure the segmentation. The larva is like that of *flavescens*, and bends the head and thorax over in the same manner. These larvæ fed readily on red clover, digging into the bases of roots or stems.

To these few but new notes on the life history is added a sketch of the newly born larva of *lineellus* (Fig. 32).

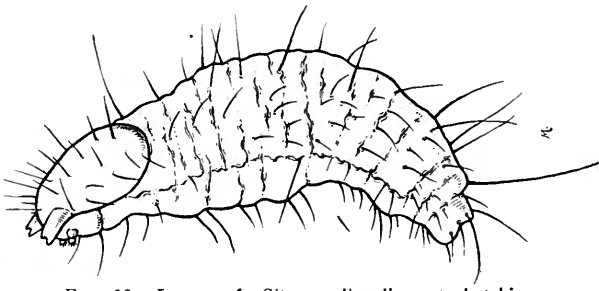

FIG. 32.—Larva of *Sitones lineellus* at hatching. Greatly enlarged.

Sitones flavescens All.

1887. Webster, F. M.—Rep. [U. S.] Comm. Agr., 1886, pp. 580–582.

1890. Schwarz, E. A.—Proc. Ent. Soc. Washington, Vol. I., pp. 248–250.

1891. Osborn, H., and Gossard, H. A.—Bull. No. 14, Iowa Agr. Exper. Sta., pp. 177, 178.

1896. Xambeu.—Mœurs et Métam. d'Insectes, Mém. 5, pp. 130–133; Extr., Ann. Soc. Linn. Lyon, Vol. XLIII., pp. 152–155.

CLOVER-ROOT MEALY BUG

Pseudococcus trifolii Forbes
(Coccus trifolii, Dactylopius trifolii)

This root-feeding mealy bug must in future be counted among the insects that kill clover plants. Its capacity in this respect has been overlooked, few entomologists having paid any attention to this inconspicuous subterranean species.

The insect occurs near the crown of the plant, as a plump oval sluggish mealy bug, with more or less of a white coating. It sucks the sap of the root by means of a minute beak. Legs and antennæ

are present, but are very small. Almost always the bugs are found in groups composed of individuals of various sizes, the largest being 2.5 mm. in length. Usually, also, these mealy bugs are accompanied by ants.

As yet we know of the presence of this species in New York, Delaware, Illinois, Michigan, Iowa, and Kentucky only, but may safely assume that it occurs in many other states.

This coccid is common on both red and white clover, and has been reported from the sugar-beet by R. H. Pettit.

Tho these mealy bugs may be found in moderate numbers on the roots of plants that appear to be healthy, the easiest way to find them is to examine clover plants that are more or less wilted. Unaided by other insects, the mealy bug often kills the clover plant. At first a few leaves droop; then as these wilt and die other leaves droop, until finally all the leaves are dead. No new leaves come forth. With sufficient rain, however, the plant revives if not too far gone. On the other hand, drought intensifies the effect of this sap-sucking insect. Furthermore, the plant may suffer at the same time from the root-borer, the leaf-weevil or the clover-louse, or from disease, old age, poor soil, overpasturage, etc.

A certain proportion of the larvæ go from the roots to the leaves to feed, and may cause the leaves to turn yellow and to die.

The fact that the injury from this insect is not wide-spread is accounted for by the feeble ability of the wingless females to go from one place to another, and the habit of the somewhat more active larvæ to stay on the same plant. I have never found the species on first-year red clover, tho its occasional occurrence on such clover might be expected; the spread of the insect is very gradual; second-year clover is affected in a sporadic way, except in a few localities where the insect has obtained a foothold; and the worst injury is done to clover, either volunteer or cultivated, that has run for more than two years.

Stages.—The winter female was described by Forbes as follows: "The body is elliptical, broadly and equally rounded at both ends, nearly circular in transverse vertical section, distinctly segmented; surface covered with waxy bloom, smooth except for a few small hairs at the anal extremity. Feet, eyes, and antennæ minute. The body is .11 of an inch long, a little more than half as wide, and a little less than half as deep; the abdomen decidedly shorter than the head and thorax; the antennæ .006 of an inch long, their length less than the distance between their bases, obscurely seven-jointed [Fig. 33, a]; the first joint as wide as long; the second a little shorter and much narrower than the first; the third and fourth a little smaller than the second and not distinctly divided; the fifth and sixth distinct, equal in length, and about equal to the first; the seventh long, cylindrical, equal to the two preceding, obtusely pointed at tip. Entire antenna minutely sparsely hairy under a high power. Eyes simple, consisting of a single ocellus and a black speck on the side of the head, directly behind the antenna, the third joint of which will about reach them.

"Legs .01 of an inch in length, each reaching about one half way to its fellow of the opposite side. Tarsus one-jointed, as long as the tibia, tapering regularly, terminating in a single stout curved claw; tibia and femur of about equal length; trochanter as long as the coxa. Legs very minutely sparsely hairy throughout. Rostrum very minute, in the form of a thick tubercle projecting downwards in front of the bases of the anterior legs, scarcely longer than wide, about half the length of the femur."

I may add, after a study of the types, that the bristle of each caudal tubercle (anal lobe) is subtended by a pair of conical projections (Fig. 34, a); the anal ring bears six long bristles; the tarsal digitules are four in number and knobbed, as in Figure 35; and the claw bears no teeth. The largest of the types is 2.5 mm. in length.

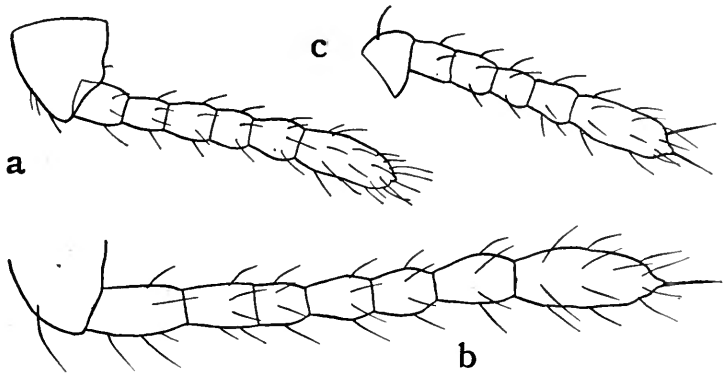

FIG. 33.—Antennæ of *Pseudococcus trifolii*: *a*, winter female; *b*, summer female; *c*, larva. Greatly enlarged.

The summer female has been described by G. C. Davis and by R. H. Pettit. The latter author writes: "The adult female measures a little more than two millimeters in length, is reddish brown in color, covered with a coating of waxy or mealy secretion. The legs are dirty yellow in color. From the sides project 15 to 17 (usually 17) waxy processes, forming a fringe around the body in the usual manner, with the shortest filaments near the head, and those near the tail considerably longer, sometimes one third as long as the body. The antennæ [Fig. 33, b] are eight-jointed; joint one is swollen, as broad as long; two and three are subequal, each about as long as one; four, five, six and seven subequal, a little over half as long as two or three; eight usually a little longer than five and six joined. There is considerable variation in four, it is sometimes smaller than five, six or seven, and sometimes slightly larger. The legs are dirty yellow, in length the tarsus of hind leg is slightly more than half the tibia, which about equals the femur. Digitules four; the two superior long and slender, the two inferior shorter and more stout. (The digitules were

not distinct, but appeared as described.) Anal tubercles [Fig. 34, b] not prominent, with a mass of small glandular spots, and bearing one long hair, with sometimes several smaller ones. Among the glandular spots are placed two conical projections or processes on each tubercle. These processes are from two to three times as long as broad at the base. Derm dotted with small round glandular spots. Back, near the caudal margin, spotted with larger round gland-

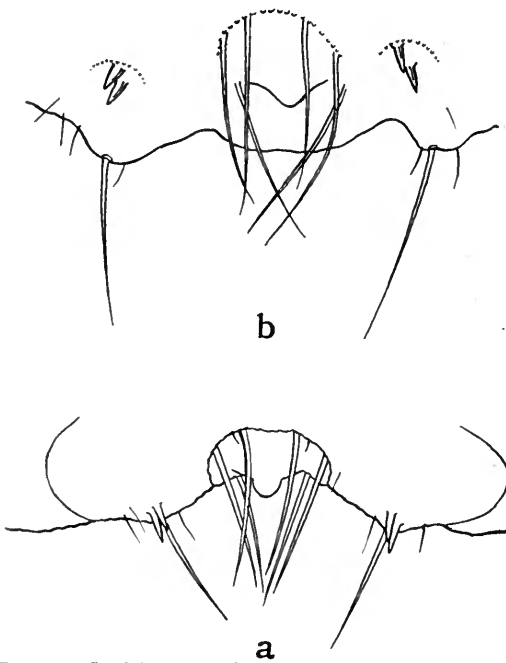

FIG. 34.—Caudal region of *Pseudococcus trifolii: a,* winter female; *b,* summer female. Greatly enlarged.

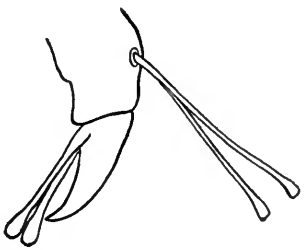

FIG. 35.—Foot of *Pseudococcus trifolii.* Greatly enlarged.

ular spots." Digitules and claws as described and figured by the writer.

The larvæ derived from the winter females are from 0.69 mm. to 0.78 mm. long and half as broad as long at birth, and are elliptical and flat, looking much like scale insects. The antennæ are six-segmented (Fig. 33, c). The minute structures of the caudal region are essentially like those of the adult females, as in Figure 34.

The male, which G. C. Davis described, is a minute two-winged insect, with two long white tail-filaments, two pairs of eyes, delicate milky-white wings, and the body thinly covered with a white powder. The head, thorax, and first two antennal segments are of a deeper red than the abdomen, legs, and remaining antennal segments. The eyes are dark reddish brown. A mouth is not evident.

The egg is elongate oval, 0.34 mm. long and 0.17 mm. broad, translucent orange-yellow at first, becoming brownish yellow later, and with a smooth surface. The egg-mass is surrounded by the cottony secretion of the mother.

The winter females that I examined all had seven antennal segments; the grown larvæ, six; the full-grown summer females, eight;

partly grown larvæ show the stages of transition from six to eight segments. In young larvæ the division between segments two and three is frequently obscure; in the large females the suture between segments two and three, or three and four, is obscure.

Mr. Pettit, who studied summer females, intimated that the winter specimens from which the original description was made were male pupæ. A study of the types, however, has shown me that they are females, some of them being full grown, tho they resemble the male pupæ to the extent of having only seven antennal segments.

The necessity for using the name *Pseudococcus* for the genus formerly called *Dactylopius* has been explained by Cockerell (Ann. Mag. Nat. Hist., Ser. 7, Vol. IX., 1902, pp. 453, 454).

Life History.—The first account of this coccid was given by Dr. Forbes, who found the species on the roots of white clover May 3, at Normal, Ill. He found that the coccids "were protected by a small yellow ant, *Lasius flavus,* in whose nests they occurred, and were carried away by them like plant-lice when the nest was exposed."

The general course of the life history has been made known by G. C. Davis from his studies in Michigan. He found the coccids abundant in clover fields April 27, and attended by *Lasius niger.* When the nests of the ant were opened, the ants carried away these coccids to another location. These were winter females. Davis put some of them on potted clover and obtained young, the first appearing May 15; these "gathered under the mother bug or collected in the flocculent mass back of her that she had secreted while producing them. They were of a light, translucent flesh-color, and much flatter than the mother."

The oviparous female makes a nest of waxy threads and places therein 75 to 300 eggs. "At first she is large and plump, but, as the pile of eggs increases, she decreases in size until at last there is nothing left of her but a little dry wrinkled piece of lifeless skin, and a mass of eggs back of her that will measure two or three times as much as she did a short time before. The time required for the eggs to hatch, and the young mealy bugs to reach maturity, is only about six or seven weeks."

The mealy bugs, tho numerous in the latter part of summer, disappear in the fall, according to Davis, who failed to find them in any stage October 15 where only a few weeks before they had been plentiful. He suggested that they had changed to the winter form and had been carried off by the ants.

Davis found also that the male, when about half or a third the size of the full-grown female, crawls up to some part of the plant above ground, spins a fluffy cocoon, and comes out, in less than a week, as a winged adult.

In Urbana, the winter females of various sizes occur on the roots of clover, attended by ants, in early spring. Our earliest dates are March 24 and 26, but the females could doubtless be found thruout

the winter. Small winter females taken March 28 and placed on the roots of potted clover thrived until June 13, then disappeared.

Of the young brought forth on the roots by winter females, some stay on the roots, but multitudes at once climb the stem of the plant and fasten themselves by the beak to the under sides of the leaves. These oval, flat, green, scalelike larvæ may stay on the leaves for a month or a little longer, growing meanwhile, or may go to the ground sooner than that. One larva taken in the field May 25 and transferred to potted clover stayed on the leaves until June 5, then disappeared, to reappear June 9 down on the stem near the ground; there it remained until June 27, when it moulted; July 5 it had disappeared for good.

The young larvæ on the leaves I found to be common June 24, July 5, and July 8; those of the first two dates were newly born and had not moulted. Larvæ on leaves June 24 were transferred to the roots July 30, where they thrived thruout August.

These individuals above ground wander about as they get older, and at length go to the ground, some dropping off the plant, perhaps by accident, while others creep down the stem to the roots. This migratory habit of the larvæ and their development on the leaves have not heretofore been noted apparently. Very likely it will be found that these aerial females are fertilized by the winged males.

While these individuals are feeding on the leaves there are others of all sizes feeding in groups on the roots; in fact, the root-feeding forms can probably be found every day in the year. The number of generations has not been made out.

No eggs have been found in spring, and in our experience they are not laid until late in the season. Our dates for oviposition in root-cages are August 31, September 1, 2, 3, 5, and October 31. We have taken eggs in the field August 31 and September 15 and 27. The eggs always hatched before winter, the egg period being either 9 or 10 days in September, and 19 days for the eggs laid October 31. The dates of hatching that we have noted are September 1, 2, 5, 10, 11, 12, 15, 18, 29, and November 19. The young from these eggs we have carried far into the winter on clover roots, and regard them as being the winter females, which are to attain their full growth in spring.

Habits.—The summer females wander about considerably on the roots and often go above ground, to resume feeding at the base of the plant in some crevice protected from the light, where they often lay eggs.

As met with in the field, this mealy bug is almost always accompanied by ants, which have made their nest about the roots of the clover plant. The species of ants found here, in this relation, are *Lasius flavus* DeG., as mentioned by Forbes, and three other common species: *Lasius niger americanus* Mayr, *Lasius interjectus* Mayr, and *Myrmica scabrinodis lobicornis* Nyl.

This coccid can get along very well without the ants, however—unlike the corn root-louse. In a root-cage the ants sometimes desert the coccids, but the latter continue to feed and to produce eggs and young as tho nothing had happened. In this instance the ants derive most of the benefit from the partnership. When an ant finds one of these mealy bugs on the ground or on the base of a plant, the ant picks it up in its jaws, carries it down under ground, and deposits it somewhere on the roots, usually not far from the base. If there are eggs with the female, the ants carry these down also and put them on rootlets.

When these coccids with ants and their cocoons are put on the surface of the soil in a root-cage, the ants begin by burrowing down along the roots. Then they carry down the coccids and the cocoons. The former they place on the roots, but the latter they carry down deeper to special chambers. If there are eggs of the coccid, the ants show many attentions to them—touching them often with the tips of the antennæ, carrying them from place to place, and often cleaning them with the mouth—in short, treating them as they do their own eggs. The coccids are left much to themselves, but occasionally an ant may be seen eating the white waxy secretion of the body of the female. Mr. E. O. G. Kelly says that this secretion is eaten only when it is newly made and fresh. Much of it is left by the ants and is used by the female to cover her eggs.

In the field the coccid is now and then seen above ground at the base of a plant when no ants are present. Occasionally, also, the coccids are found working on the roots without ants, there being either no sign of ants or else a nest that appears to be deserted.

This coccid spreads very slowly, as has been said. Newly born larvæ climb the stem to the leaves, but seem not to leave the plant to any great extent, tho a few may be found on such neighboring plants as are easily accessible. The summer females frequently go above ground and wander about a little, tho they are sluggish. Probably the species is spread by ants faster and farther than by any other means.

No natural enemies of this mealy bug are as yet known.

Up to the present the species has been of only minor economic importance.

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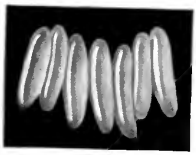
EXPLANATION OF PLATE I.

FIG. 1 to 3.—Clover Seed-midge, *Dasyneura leguminicola*: Fig. 1, larva, ventral aspect; 2, sternal spatula; 3, female midge. All greatly enlarged.

FIG. 4 to 8.—Clover Leaf-midge, *Dasyneura trifolii*: Fig. 4, galls on white clover, also larvæ and cocoons, natural size; 5, eggs; 6, larva, dorsal aspect; 7, sternal spatula; 8, female midge. Fig. 5 to 8 are greatly enlarged.

FIG. 9 to 11.—Clover Seed-caterpillar, *Enarmonia interstinctana*: Fig. 9, larva at work in head of red clover, natural size; 10, larva, enlarged; 11, moth, enlarged.



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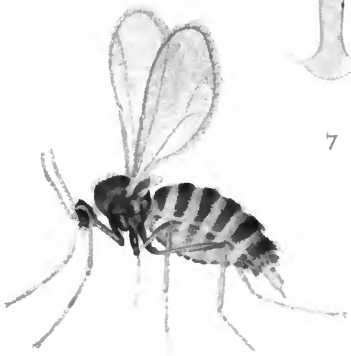

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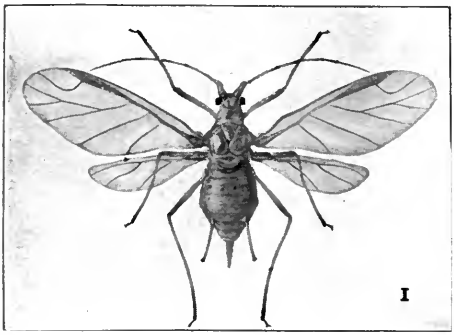
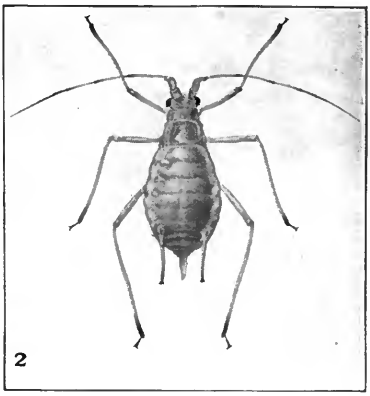
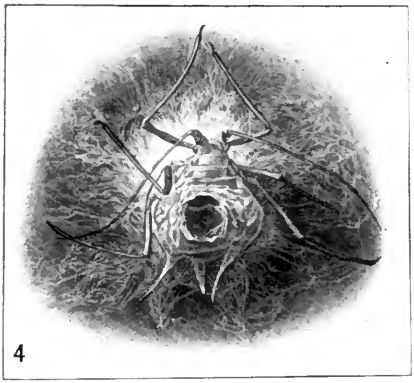
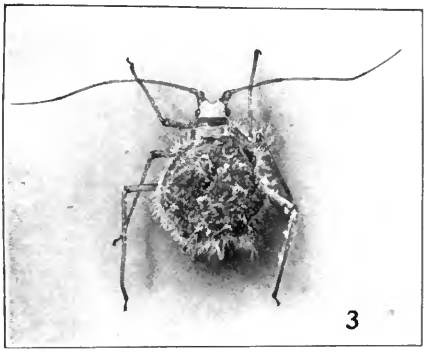
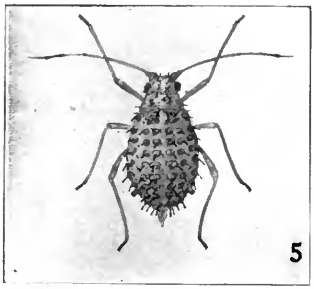
PLATE I.











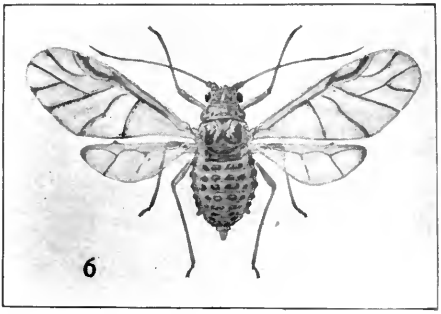


PLATE II.

FIG. 1 to 4.—Clover-louse, *Macrosiphum pisi*: Fig. 1, winged viviparous female; 2, wingless viviparous female; 3, aphid attacked by fungus, *Empusa aphidis*; 4, empty skin after emergence of parasite—*Aphidius*.

FIG. 5 and 6.—Clover Callipterus, *C. trifolii*: Fig. 5, wingless viviparous female; 6, winged viviparous female.